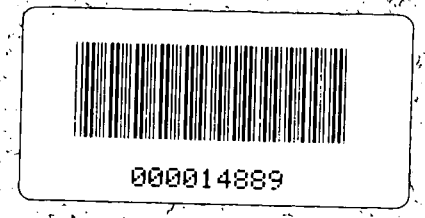

FINAL

TREATABILITY STUDY WORK PLAN FOR OXIDATION/REDUCTION PROCESSES

ROCKY FLATS PLANT

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

July 1992

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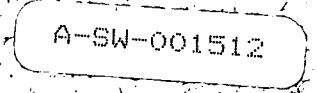

FINAL

TREATABILITY STUDY WORK PLAN FOR OXIDATION/REDUCTION PROCESSES

ROCKY FLATS PLANT

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

July 1992

TITLE: Table of Contents

Approved By:

Name / / (Date)

APPENDIX C (Continued)

APPENDIX C (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

The following is a list of acronyms used throughout this work plan.

AA	atomic absorption
Al	aluminum
ARARs	Applicable or Relevant and Appropriate Requirements
As	arsenic
AWQC	Ambient Water Quality Criteria
Ba	barium
BACK	Statewide Background Minimum
Be	beryllium
CCB	Continuing Calibration Blank
CCR	Colorado Code of Regulations
CCV	Continuing Calibration Verification
Cd	cadmium
CDH	Colorado Department of Health
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHWA	Colorado Hazardous Waste Act
CLP	Contract Laboratory Program
cm	centimeters
CMS	corrective measures study (or studies)
COC	chain of custody
CWQCC	Colorado Water Quality Control Commission
Cr	chromium
CRDL	Contact Required Detection Limit
CRP	community relations plan
CVA	Cold Vapor Analysis
CWA	Clean Water Act
DOE	Department of Energy
DOT	Department of Transportation
DQO	data quality objective
DWR	Colorado Division of Water Resources
EC	electrical conductivity
EMD OPS	Environmental Management Department Operating Procedures
EPA	Environmental Protection Agency
ER	environmental restoration
Fe	iron
FIDLER	Field Instrument for Detection of Low Energy Radiation
FS	feasibility study
FSP	field sampling plan
ft	foot/feet

GC/MS	gas chromatography/mass spectroscopy
GFAA	Graphite Furnace Atomic Absorption
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
GT	greater than
HEA	Health Effects Assessment
Hg	mercury
HSL	Hazardous Substance List
HSO	Health and Safety Officer
HSP	Health and Safety Plan
IAG	Inter-Agency Agreement
ICB	Initial Calibration Blank
ICP	inductively coupled plasma
ICS	Interference Check Sample
ICV	Initial Calibration Verification
IDL	Initial Detection Limit
in	inches
in/hr	inch(es) per hour
kg	kilograms
km	kilometer
KSID	Lower State Interceptor Ditch
l or L	liter
lb	pounds
LCS	Laboratory Control Sample
LT	less than
M	molar
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mCi/km^2	microcurie per square kilometer
MDAs	minimum detectable activities
mg/l or mg/L	milligrams per liter
mi	mile
ml or mL	milliliter
Mn	manganese
µm	micrometers
mm	millimeters
Mn	manganese
MS	mass spectroscopy
MSD	matrix spike duplicate
MSL	mean sea level
mv	millivolt
Ni	nickel
NRC	Nuclear Regulatory Commission
OU	Operable Unit
PARCC	precision, accuracy, representativeness, completeness, and comparability
Pb	lead

PB	preparation blank
pCi/g	picocuries per gram
pCi/l or pCi/L	picocuries per liter
PM	Project manager
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
Pu	plutonium
PuO_2	Plutonium Dioxide
QAA	Quality Assurance Addendum
QAO	Quality Assurance Officer
QA/QC	Quality Assurance/Quality Control
QAPjP	Quality Assurance Project Plan
QAPP	Quality Assurance Project Plan
Ra	radium
RAD	radiation
RCRA	Resource Conservation and Recovery Act
redox	reduction/oxidation
RFDs	Reference doses
RFEDS	Rocky Flats Environmental Database System
RFI	RCRA facility investigation
RFP	Rocky Flats Plant
RI	remedial investigation (CERCLA)
RMSF	Rocky Mountain Spotted Fever
RPD	relative percent difference
SAS	Special Analytical Services
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act of 1986
Sb	Antimony
SDWA	Safe Drinking Water Act
Se	selenium
SOP	Standard Operating Procedure
SOPA	Standard Operating Procedure Addendum
SOW	Statement of Work
SPHEM	Superfund Public Health Evaluation Manual
SW	Surface water
TAL	target analyte list
TBC	to be considered
TDS	total dissolved solids
TSP	Rocky Flats Site-Wide Treatability Studies Plan
TSR	Treatability Study Report
TSSP	Treatability Study Sampling Plan
TSWP	Treatability Study Work Plan
U	uranium
uCi/m^2	microcurie per square meter

USID	Upper South Interceptor Ditch
USPS	United States Postal Service
UV	ultraviolet
v	volt
VOA	volatile organic analysis
VOC	volatile organic compound
WQC	Water Quality Criteria
WQCC	Water Quality Control Commission

EXECUTIVE SUMMARY

This Treatability Study Work Plan (TSWP) describes the steps necessary to demonstrate the effectiveness of different types of oxidation/reduction (redox) processes followed by precipitation and filtration in removing metals and radionuclides from surface water and groundwater at the Rocky Flats Plant (RFP).

Existing analytical records for samples collected at the RFP indicate that surface water and groundwater in some areas of the RFP are contaminated with metals and radionuclides. In most cases, the contaminant concentrations are relatively low–in many cases below the intrinsic solubilities of the metal hydroxides and other relatively insoluble metal salts. The objective of the Redox Treatability Study described in this Work Plan is to evaluate different redox processes to determine which is most effective in adjusting the metals and radionuclides in solution to the oxidation state that will result in the formation of the lowest solubility salt (usually the lowest oxidation state), and then to precipitate the metals and radionuclides as a low-solubility salt. In some cases, coprecipitation with alum acting as a coprecipitant, will be used to enhance the effectiveness of the precipitation step.

The target metals and radionuclides, which are in solution in surface water and groundwater at the RFP, include a broad range of materials. The known chemistry of these materials indicates that a single reducing agent or oxidation step will not be equally effective in removing all of the target metals and radionuclides. For this reason, the experiment design includes the use of several reducing agents. In addition, oxidation will be tested to determine its effectiveness for iron and manganese removal. Based on previous experience, oxidation is not considered effective for the removal of other target constituents. In Section 5, Experiment Design and Procedures, the targeted metals and radionuclides for each experiment task are discussed in more detail.

Experiment Task 1 (described in Section 5) is designed to prepare solutions and set up the laboratory. Tasks 2 through 9 are designed to screen the specified reduction, precipitation, and oxidization agents for effectiveness in removing metals and radionuclides. Task 10 is designed to restore the laboratory to pre-experiment conditions.

Blanks (distilled water) are used as samples in some of the laboratory tests to determine if low levels of contamination in the reagents used affect the analytical results (for example, chromium contamination in iron salts used as a reagent).

Locations for collecting surface water and groundwater samples for use in the Redox Treatability Study are described in Appendix A, the Sampling and Analysis Plan. The sampling locations were chosen to provide a representative range of contamination for the targeted constituents. Compositing of water from different sampling points was avoided to avoid dilution of the more highly contaminated locations. Finding sampling locations with a range of concentrations of the targeted constituents is important because the processes being tested are of two basically different types: the precipitation reactions will remove targeted constituents down to a limited solubility, regardless of the initial concentration of targeted constituents, while the coprecipitation reactions will remove a given percentage of the initial concentration of the targeted constituents.

In some cases, it was impossible to find a sampling location with all of the targeted constituents at the desired contamination level. In these instances, a sampling location was chosen that would result in the desired contamination level of the largest number of targeted constituents, with extra consideration given to the constituents which are expected to be the most difficult to remove to potential contaminant standards levels using the selected redox/precipitation processes.

Results of the treatability study will be recorded in a report containing the raw data from the experiment as well as conclusions regarding the experiment's effectiveness. The planned table of contents of the Treatability Study report is included in Section 11 of this document.

If this Treatability Study shows that redox processes followed by precipitation/coprecipitation are an effective means of reducing metals and radionuclides in surface water and groundwater at the RFP, it is anticipated that the selected processes will be tested in a demonstration unit at the RFP.

1.0 INTRODUCTION

This document presents the work plan for conducting redox treatability tests at the U.S. Department of Energy (DOE) Rocky Flats Plant.

The final Inter-Agency Agreement (IAG) stated that DOE will develop a Treatability Studies Plan (TSP) to evaluate candidate remedial technologies for the general types of contamination encountered sitewide at the RFP. The TSP (DOE, 1991a) presented treatment technologies applicable to remediation efforts at two or more operable units (OUs). The treatability studies are designed to provide information for the individual OU Feasibility Study/Corrective Measures Studies (FS/CMS) without having to perform individual OU-specific treatability studies.

The TSP identified redox as one of the technologies to be tested. This technology was selected for removal of metals and radionuclides in groundwater and surface water. The purpose of this work plan is to describe the testing procedures for the following oxidation/reduction processes:

- Air oxidation
- Sodium bisulfite reduction
- Stannous chloride reduction
- Ferrous sulfate reduction

Testing of the redox processes will be coupled with precipitation/coprecipitation and flocculation process testing. In addition, the purpose of the treatability study is to establish basic limitations of the oxidation/reduction technology for use in the technologies and alternatives evaluation phases of the FS/CMS to be conducted at each OU.

1.1 OBJECTIVES

The overall objective of the treatability study is to evaluate the effectiveness of the various redox processes as potential treatment alternatives in reducing the volume, toxicity, or mobility to hazardous substances, pollutants, and contaminants from Rocky Flats surface water and groundwater. The individual processes are a set of independent studies that involve similar chemical processes. Specific testing objectives include conducting screening tests of these various processes and determining treatment parameters to identify the most promising process and combination of treatment parameters for reducing the concentration of metals and radionuclides in the onsite waters at Rocky Flats. All data will be checked in accordance with EPA's Functional Guidelines for Laboratory Data Evaluation (EPA, 1988). Measurements of performance are described in Subsection 8.1.

2.0 PROJECT DESCRIPTION

This section provides background information on the Rocky Flats Plant (RFP) site and summarizes the contaminants of concern for this treatability study. A discussion of the type of study to be conducted is also included.

2.1 BACKGROUND INFORMATION

The RFP is a government-owned, contractor-operated facility that is part of the nationwide nuclear weapons production complex. The primary mission of the RFP is to fabricate nuclear weapon components from plutonium, uranium, and nonradioactive metals (principally beryllium and stainless steel). The nuclear weapon component parts made at the Plant are shipped elsewhere for final assembly. The RFP also reprocesses components for recovery of plutonium after they are removed from obsolete weapons. Other activities at the RFP include research and development in metallurgy, machining, nondestructive testing, chemistry, physics, engineering, and environmental management.

Both radioactive and nonradioactive wastes are generated in the production process. Current waste handling practices involve onsite and offsite recycling of hazardous materials, onsite storage of hazardous and radioactive mixed wastes, and offsite disposal of solid radioactive materials at another DOE facility. However, both storage and disposal of hazardous and radioactive wastes occurred onsite in the past. Preliminary assessments under the Environmental Restoration (ER) Program identified some of the past onsite storage and disposal locations as potential sources of environmental contamination.

Details concerning the site's location, climatology and meteorology, and geology and hydrogeology that can potentially affect the remediation methodology and implementation are included in the

following subsections. Various studies have been conducted at the RFP to characterize environmental media and to assess the extent of radiological and chemical contaminant releases to the environment. More information on these subjects may be found in the TSP.

2.1.1 Location

The RFP is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver (Figure 2-1). Other surrounding cities include Boulder, Westminster, and Arvada, which are located less than 10 miles to the northwest, east, and southeast, respectively. Major buildings are located within the approximately 400-acre security area of the RFP. The security area is surrounded by a buffer zone of approximately 6,150 acres (Figure 2-2).

2.1.2 Climatology and Meteorology

The area surrounding the RFP has a semiarid climate characteristic of much of the central Rocky Mountain region. Approximately 40 percent of the 15-inch annual precipitation falls during the spring season—much of it as wet snow. Thunderstorms (occurring from June to August) account for an additional 30 percent of the annual precipitation. Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively. Snowfall averages 85 inches per year, falling from October through May (DOE, 1980).

2.1.3 Geology and Hydrogeology

The stratigraphic section that pertains to the RFP includes, in descending order, unconsolidated surficial units (Rocky Flats Alluvium, various other alluvial deposits, valley fill alluvium, and colluvium), the Arapahoe Formation, the Laramie Formation, and Fox Hills Sandstone. Groundwater occurs under unconfined conditions in both the surficial and shallow bedrock units. In addition, confined groundwater flow occurs in deeper bedrock sandstones (such as the Fox Hills Sandstone formation). More information on these subjects may be found in the TSP.

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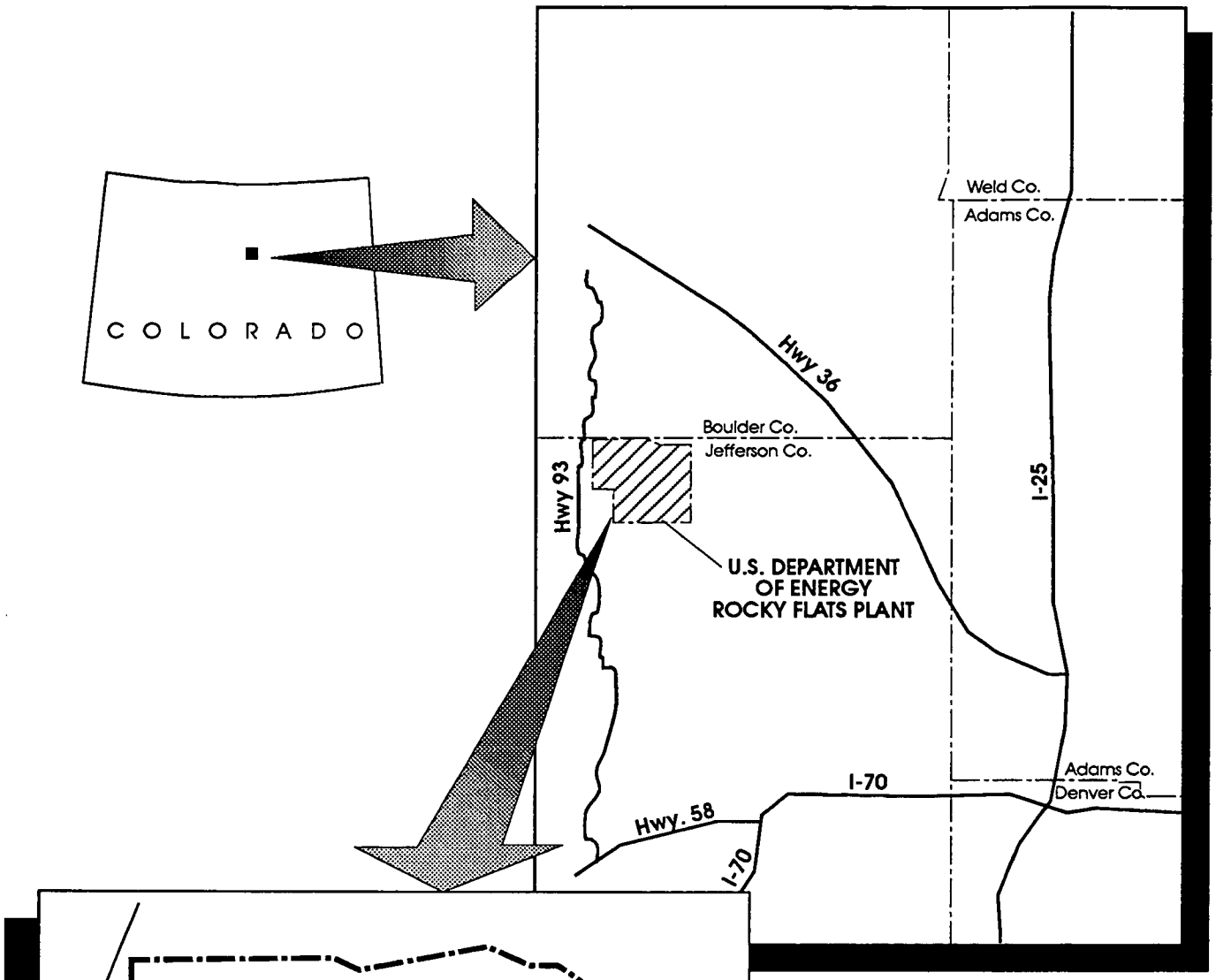
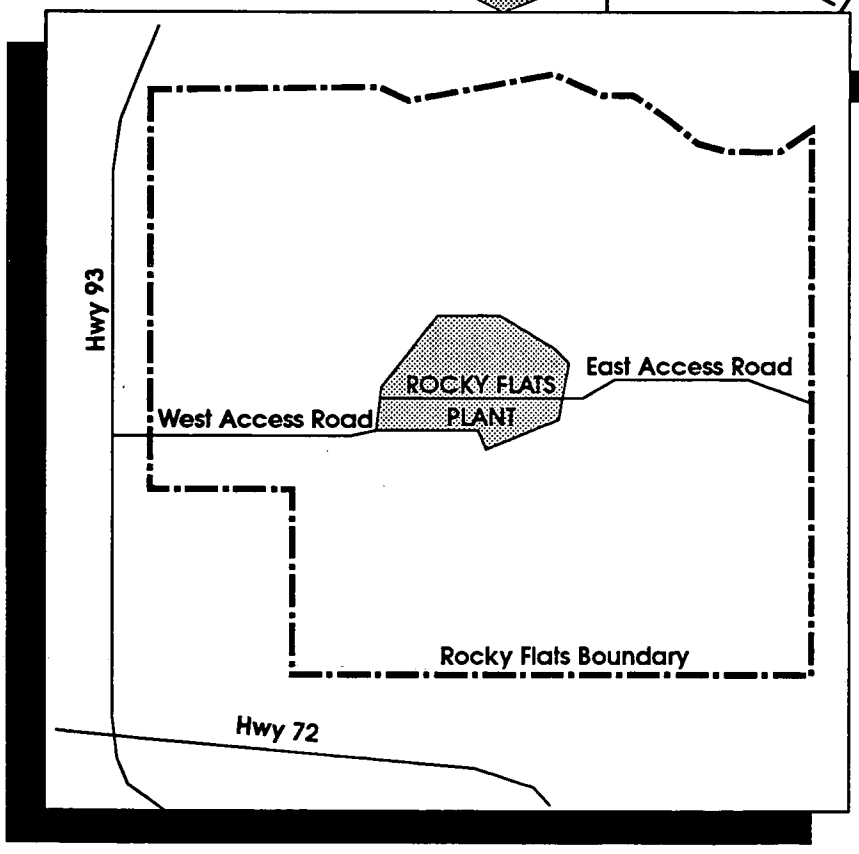
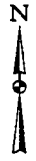
	10/31/91	APPROVED BY		12/13/91	

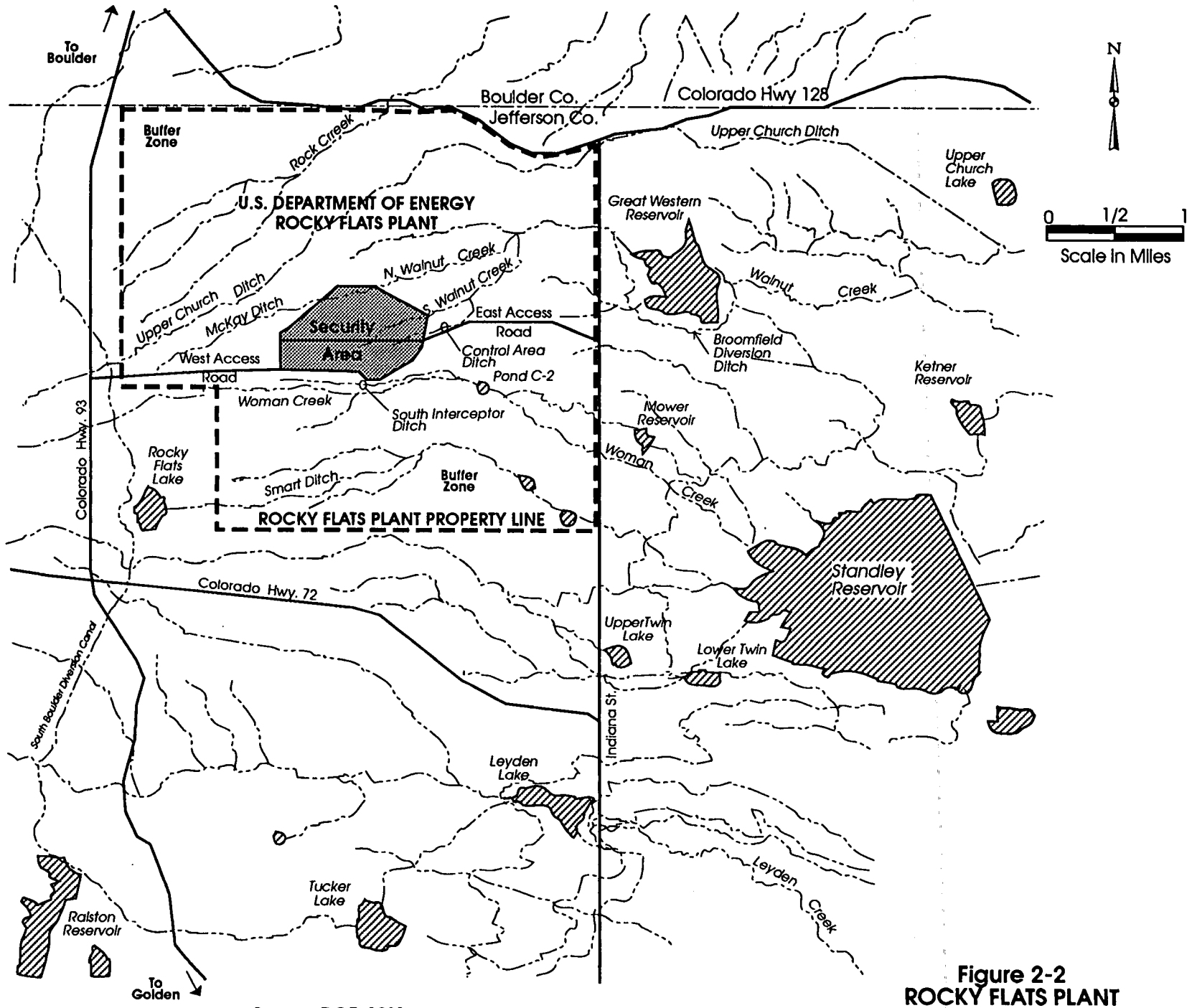






Source: DOE, 1991a

Figure 2-1
LOCATION OF
ROCKY FLATS PLANT



Source: DOE, 1991a

Figure 2-2
ROCKY FLATS PLANT
BOUNDARIES AND BUFFER ZONE

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	10/31/91	APPROVED BY		12/3/91	

2.2 TREATMENT GOALS/ARARs

The TSP presented the potential Applicable or Relevant and Appropriate Requirements (ARARs) and to-be-considered standards (TBC) for the RFP. This section presents a summary of the potential ARARs/TBCs associated with the groundwater and surface water. The summary of potential ARARs/TBCs for groundwater and surface water is based on chemicals suspected to be present at RFP and the following current federal and state health and environmental statutes and regulations:

- Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) applied to both surface and groundwater.

- Clean Water Act (CWA) Water Quality Criteria (WQC) applied to surface water.

- RCRA Subpart F Groundwater Concentration Limits (40 CFR 264.94) applied to groundwater.

- Colorado Department of Health (CDH) surface water standards for Woman Creek and Walnut Creek (5 CCR 1002-8, Section 3.8.0, amended February 15, 1990) applied to surface water.

- CDH Water Quality Control Commission (WQCC) statewide and classified groundwater area standards (5 CCR 1002-8, Section 3.11) applied to groundwater.

In addition to the potential ARARs/TBCs, health effects assessment (HEA) criteria or "action levels" developed by Environmental Protection Agency (EPA) for carcinogens and systemic toxicants were considered as possible or potential cleanup goals in the TSP.

Where ARARs did not exist for a particular chemical or where existing ARARs are not protective of human health or the environment, TBC criteria, guidances, proposed standards, and advisories were evaluated for use.

The goal of the Treatability Study will be to evaluate various types of redox processes and precipitation processes for their effectiveness in removing metals and radionuclides from groundwater and surface water. The resulting conclusions will be used in support of the FS/CMS.

Sitewide potential ARARs/TBCs were selected for comparison to sitewide maximum and minimum analyte concentrations. This process is described in the following subsection.

2.3 DESCRIPTION OF CONTAMINANTS

Summaries of the potentially hazardous substances found within groundwater, surface water, soils, and wastes at the RFP were also presented in the TSP. The TSP identified metals and radionuclides as contaminants of concern in groundwater and surface water for several OUs. This section presents the contaminants to be addressed by the redox treatability study.

Potential standards were selected for comparison to maximum and minimum analyte levels. MCLs were selected as the principal standards for both surface water and groundwater. The appropriate state standard was used for groundwater where there was no MCL. The state agricultural value was not considered in determining the appropriate state standard. In cases where the state standard was below the current analytical detection limit, the detection limit was used as the default value. For surface water, the lowest federal Water Quality Criteria (WQC) was used where there was no MCL, unless the WQC was below detection limit, in which case the detection limit was used. The appropriate state standard was used for surface water where there was no MCL or Ambient Water Quality Criteria (AWQC), unless this value was below detection limit, in which case the detection limit was used. The lowest systemic or carcinogenic HEA criterion was used for surface water and groundwater for those chemicals which had no MCL, WQC, or state standard. Where HEA criteria were below the detection limit, the detection limit was used.

Table 2-1 presents the maximum and minimum concentrations of all metals and radionuclides analyzed for and the potential standard associated with each contaminant. Table 2-2 lists the OUs that contain these contaminants in levels above the potential standard.

The metals exceeding potential ARARs/TBCs in groundwater included antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. Of these metals, arsenic, cadmium, chromium, iron, lead, manganese, and selenium have been detected in two or more OUs. Therefore, the redox treatability study will address this subset of detected metals for groundwater.

The only radionuclide in groundwater exceeding the potential standards was gross alpha activity. Gross alpha was detected in three OUs; therefore, alpha-emitting radionuclides such as Pu, U, and Ra are contaminants of concern for this treatability study.

The metals exceeding potential standards in surface water included aluminum, arsenic, antimony, barium, beryllium, cadmium, chromium, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. All of the metals, except silver and zinc, have been detected in two or more OUs. Therefore, the redox treatability study will address this subset of detected metals for surface water.

The radionuclides in surface water exceeding the potential standards were gross alpha activity, americium 241, gross beta activity, plutonium 239 and 240, radium 226, radium 228, tritium, and uranium (total). Only americium 241 and radium 228 have not been detected in two or more OUs. Therefore, the redox treatability study will address the subset of detected radionuclides for surface water.

2.4 TREATABILITY STUDY OVERVIEW

General laboratory-scale testing will be conducted on all of the redox processes to determine if any of them are not suitable for metal or radionuclide removal, and to determine the relative

TABLE 2-1[a]

ANALYTE CONCENTRATIONS AND ARARS

Parameter	Groundwater (mg/l) Maximum[b]		Minimum[c]	Potential ARAR	Surface Water (mg/l) Maximum[b]		Minimum[c]	Potential ARAR
METALS (TOTAL AND DISSOLVED)								
Aluminum	4.75	BR (B)	0.200	5.0	293	(A)	0.200	0.200
Antimony	0.208	(E)	0.060	0.01	0.416	(A)	0.060	0.146
Arsenic	1.6	J BR (B)	0.010	0.05	1.03	(A)	0.010	0.05
Barium	0.9321	(B)	0.200	1.0	87.6	(E)	0.200	1.0
Beryllium	0.029	(E)	0.005	0.1	0.09	(E)	0.005[d]	0.005
Cadmium	0.0352	BR (F)	0.005	0.01	25	(A)	0.005	0.01
Calcium	1900	BR (F)	5.000		51200	(E)	5.000	
Cesium	0.4	(G)	1.000		12	(A)	1.000	
Chromium	0.172	BR (F)	0.010	0.05	0.298	(A)	0.010	0.05
Cobalt	0.14	(E)	0.050	0.05	0.489	(A)	0.050	
Copper	0.9515	(E)	0.025	1.0	0.908	(E)	0.025	1.0
Iron	57.1	(F)	0.100	0.3	3220	(A)	0.100	0.30

[a]Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.
[b]Maximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.
[c]Value given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Version 2.1 (DOE, 1991).
[d]Present in laboratory blank.

Notes: J = Analyzed below detection limit.
BR = Bedrock (including some weathered bedrock).

TABLE 2-1[a]

ANALYTE CONCENTRATIONS AND ARARS
(Continued)

Parameter	Groundwater (mg/l) Maximum[b]		Groundwater (mg/l) Minimum[c]	Groundwater (mg/l) Potential ARAR	Surface Water (mg/l) Maximum[b]		Surface Water (mg/l) Minimum[c]	Surface Water (mg/l) Potential ARAR
METALS (TOTAL AND DISSOLVED) (continued)								
Lead	0.21	J BR (B)	0.005	0.05	0.516	(A)	0.005	0.050
Lithium	0.7	(E)	0.100		85.2	(A)	0.100	
Magnesium	788	(F)	5.000		7540	(E)	5.000	
Manganese	6	(F)	0.015	0.05	27.7	(A)	0.015	0.050
Mercury	0.006	(E)	0.0002	0.002	3.97	(E)	0.0002	0.002
Molybdenum	1.92	BR (B)	0.200		0.333	(A)	0.200	
Nickel	11.7	(E)	0.040	0.2	0.646	(A)	0.040	0.1
Potassium	633	BR (F)	5.000		4260	(A)	5.000	
Selenium	3.2	(E)	0.005	0.010	0.55	(A)	0.005	0.010
Silicon	10.7	(F)						

[a]Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.
[b]Maximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.
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Notes: J = Analyzed below detection limit.
BR = Bedrock (including some weathered bedrock).

TABLE 2-1[a]

ANALYTE CONCENTRATIONS AND ARARS
(Continued)

Parameter	Groundwater (mg/l) Maximum[b]		Minimum[c]	Potential ARAR	Surface Water (mg/l) Maximum[b]		Minimum[c]	Potential ARAR
METALS (TOTAL AND DISSOLVED) (continued)								
Silver	0.13	(B)	0.010	0.050	0.148	(A)	0.010	0.050
Sodium	924	(F)	5.000		173000	(E)	5.000	
Strontium	7.7	BR (B)	0.200		11.9	(A)	0.200	
Thallium	0.016	(E)	0.050					
Tin	1.121	(E)	0.200		1.53	(A)	0.200	
Vanadium	0.092	BR (B)	0.050		1.65	(A)	0.050	
Zinc	4.39	BR (F)	0.020	5.0	28.7	(E)	0.020	5.0

[a]Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.
[b]Maximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.
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[d]Present in laboratory blank.

Notes: J = Analyzed below detection limit.
BR = Bedrock (including some weathered bedrock).

TABLE 2-1[a]

ANALYTE CONCENTRATIONS AND ARARS
(Continued)

Parameter	Groundwater (pCi/l) Maximum[b]		Minimum[c]	Potential ARAR	Surface Water (pCi/l) Maximum[b]		Minimum[c]	Potential ARAR
RADIONUCLIDES (TOTAL AND DISSOLVED)								
Americium 241	2.3	(E)	0.01		90	(A)	0.01	30
Cesium 137	3.1	(E)	1		25	(E)	1	
Gross Alpha	811	BR (E)	2	15	1900	(A)	2	15
Gross Beta	368	(F)	4		3800	(A)	4	5
Plutonium 239 +240	4.6	(G)	0.01	15(a)	120	(A)	0.01	15(a)
Radium 226	0.8	(E)(G)	0.5		30	(A)	0.5	5(b)
Radium 228					24	(A)	0.5	5(b)
Strontium 89 + 90	4.59	(G)	1.0		37	(C)	1.0	
Strontium 90	5.7	(G)	1.0		3.2	(A)	1.0	8

[a]Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.
[b]Maximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.
[c]Value given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Version 2.1 (DOE, 1991).
[d]Present in laboratory blank.

Notes: J = Analyzed below detection limit.
BR = Bedrock (including some weathered bedrock).

TABLE 2-1[a]

ANALYTE CONCENTRATIONS AND ARARS
(Continued)

Parameter	Groundwater (pCi/l) Maximum[b]		Minimum[c]	Potential ARAR	Surface Water (pCi/l) Maximum[b]		Minimum[c]	Potential ARAR
RADIONUCLIDES (TOTAL AND DISSOLVED) (continued)								
Tritium	7710	(F)	400	20000	13000	(A)	400	500
Uranium 233 + 234	723	(G)	0.6		861	(A)	0.6	
Uranium 235	9	(F)	0.6		65.5(A)		0.6	
Uranium 235 + 236	0.009	(G)	0.6		1.192	(G)	0.6	
Uranium 238	190	(F)	0.6		366	(A)	0.6	
Uranium (Total)	63.7	(B)	0.6		1023	(A)	0.6	5

[a]Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.
[b]Maximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.
[c]Value given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Version 2.1 (DOE, 1991).
[d]Present in laboratory blank.

Notes: J = Analyzed below detection limit.
BR = Bedrock (including some weathered bedrock).

TABLE 2-1[a]

ANALYTE CONCENTRATIONS AND ARARS
(Concluded)

Parameter	Groundwater (pCi/l) Maximum[b]	Groundwater (pCi/l) Minimum[c]	Groundwater (pCi/l) Potential ARAR	Surface Water (pCi/l) Maximum[b]	Surface Water (pCi/l) Minimum[c]	Surface Water (pCi/l) Potential ARAR

References:

Note: Analytical data received prior to October 1988 not subjected to validation procedure. Some of the contaminant values reported in this table have not yet been validated, and the analyte list may be changed after the data are validated.

(A) EG&G. February 22, 1991a, Surface Water and Sediment Geochemical Characterization Report, Draft Copy.
(B) U.S. DOE. April 2, 1990c, Final Phase II Remedial Investigation/Feasibility Study Workplan (Alluvial), OU 2, Draft Copy.
(C) U.S. DOE. January 11, 1991a, Proposed Surface Water Interim Measures, Interim Remedial Action Plan/Environmental Assessment and Decision Document South Walnut Creek Basin, OU 2, Final Draft.
(D) U.S. DOE. January 24, 1991b, Phase II Remedial Investigation/Feasibility Study Workplan (Bedrock), OU 2, Draft Copy.
(E) U.S. DOE. October 1990d, Phase III Remedial Investigation/Feasibility Study Workplan 881 Hillside Area, OU 1, Final Draft.
(F) EG&G. March 1, 1991b, 1990 Annual RCRA Groundwater Monitoring Report for Regulated Units at Rocky Flats Plant, Draft Copy.
(G) EG&G. May 1991, Unpublished data (see note to reference).

[a]Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.
[b]Maximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.
[c]Value given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Version 2.1 (DOE, 1991).
[d]Present in laboratory blank.

Notes: J = Analyzed below detection limit.
BR = Bedrock (including some weathered bedrock).

TABLE 2-2

LIST OF CHEMICALS REPORTED ABOVE ARARs IN TWO OR MORE OPERABLE UNITS

	Operable Units (Two or More)	
Contaminant	Reported in Groundwater	Reported in Surface Water
METALS		
Aluminum		1,2,4,5,6,7 USID
Antimony		1,2,4,6, LSID
Arsenic	2,4	4, BACK
Barium		1,4,6,7, USID, LSID
Beryllium		1,6, LSID
Cadmium	1,4	1,4,6 LSID
Chromium	1,2,4,7	1,2,4,7 USID, LSID
Iron	1,2,4	1,2,4,5,6,7, LSID, USID
Lead	2,4	1,2,4,5,6,7, LSID, USID
Manganese	1,2,4,7	1,2,4,5,6,7, LSID, USID
Mercury		1,4,6
Nickel		4,6, BACK
Selenium	1,2,4,7	1,2,4,5,6,7, LSID
RADIONUCLIDES		
Gross Alpha	1,2,4	1,2,4,6,7, LSID, USID
Gross Beta		1,2,4,5,6,7, LSID, USID
Plutonium 239 + 40		2,4
Radium 226		1,4,7, LSID, BACK
Tritium		1,2,4,5,6,8
Uranium (total)		1,2,4,5,6,7, USID

Notes: BACK = Sitewide Background Maximum
USID = Upper South Interceptor Ditch
LSID = Lower South Interceptor Ditch

Source: DOE, 1991a.

effectiveness of the processes. The actual testing procedures are detailed in Section 5.0 of this document.

Upon completion of the redox treatability study, the results will be reviewed in order to determine if there is sufficient information to evaluate the technology for the FS/CMSs without further testing for various OUs. If more information is necessary, the information needed will be described in the treatability study summary report. The review process is described in Section 8.0 of this document.

3.0 REMEDIAL TECHNOLOGY DESCRIPTION

This section provides a general overview of the redox remedial technology.

The chemical redox process involves a change of the oxidation state of the reactants; the oxidation state of one reactant is increased while that of the other reactant is reduced. Common oxidizing agents include ozone, hypochlorite, and chlorine. Common reducing agents include sodium borohydride, sulfur dioxide, and ferrous sulfate (EPA, 1985, 1986).

The purpose of redox treatment of inorganic compounds (excluding heavy metals) in water is generally to break a compound into simpler, less toxic constituents. Examples are the conversion of sodium cyanide to carbon dioxide and nitrogen using alkaline chlorination, and the conversion of ammonium to nitrogen and water using sodium nitrite (Marin et al., 1979).

The use of redox treatment of waste streams containing heavy metals is typically required to enhance a subsequent precipitation step. The redox reaction is used to adjust the metal to an oxidation state that will result in the formation of an insoluble metal salt precipitate that can then be physically removed from the bulk of the aqueous waste stream. An example is the use of sulfur dioxide to reduce hexavalent chromium to trivalent chromium, which is then precipitated as chromous hydroxide. In general, the use of redox in conjunction with precipitation for the removal of heavy metals is a well-established water treatment method.

The applicability of each process to remove metals and radionuclides is listed below. The processes are described in more detail in Section 5.0 of this report.

- **Sodium Bisulfite Reduction**—The sodium bisulfite reduction process will use sodium bisulfite as a reducing agent and is expected to alter the valence states of chromium and plutonium to allow precipitation. This process may also alter the valence states of selenium, mercury, and uranium to allow precipitation.

- **Stannous Chloride Reduction**—The stannous chloride reduction process will use stannous chloride as a reducing agent and is expected to alter the valance states of mercury and plutonium to allow precipitation. This process may also alter the valence states of chromium, selenium, and uranium to allow precipitation.

- **Ferrous Sulfate Reduction**—The ferrous sulfate reduction process will use ferrous sulfate as a reducing agent and is expected to alter the valence states of chromium, selenium, and plutonium to allow precipitation. This process may also alter the valance states of uranium and mercury to allow precipitation.

- **Air Oxidation**—The oxidation process will use air as an oxidizing agent and is expected to alter the valence state of iron to allow precipitation to occur. This process may also alter the valence state of manganese.

- **Precipitation/Coprecipitation**—Because many of the target constituents are at or below solubility limits, precipitation or coprecipitation are necessary processes in the removal of metals and radionuclides from the surface water and groundwater. This treatability study will use the following precipitation/coprecipitation approaches:

  - Barium sulfate coprecipitation
  - Lime precipitation
  - Iron coprecipitation
  - Alum coprecipitation

Various polymers will be tested for their effectiveness as flocculation aids for the precipitation and coprecipitation processes.

4.0 DATA QUALITY OBJECTIVES

The primary objective of the treatability study is to evaluate the relative effectiveness of four technologies in removing metals and radionuclides from contaminated water. These technologies consist of:

- Oxidation
- Reduction using stannous chloride, sodium bisulfite, and ferrous sulfate
- Precipitation
- Coprecipitation

Use of these technologies relies on two complementary approaches for removing metals and radionuclides: (1) oxidation/reduction of constituents to insoluble forms which can be readily removed from the water by settling or filtration and (2) oxidation/reduction to less soluble forms which can be subsequently removed by precipitation or coprecipitation, followed by settling or filtration. It is expected that process testing will also identify metal and radionuclide removal efficiencies by oxidation/reduction. In addition, process testing may identify the efficiencies of precipitation or coprecipitation without the use of oxidations/reductions.

Data quality objectives (DQOs) express qualitative and quantitative statements describing the quality and quantity of data required by the treatability study. Developing DQOs relies on the following three stage process:

- **Stage 1**–Identify decision types
- **Stage 2**–Identify data uses/needs
- **Stage 3**–Design a data collection program

4.1 STAGE 1—IDENTIFYING DECISION TYPES

Of the three stages above, Stage 1 has already been completed as part of the TSP. The Final TSP Report identifies the treatability studies program goals and objectives and the technical approach. The overall objective of the treatability studies program is to provide treatability study information to support the Feasibility Studies or Corrective Measure Studies (FS/CMS) to be conducted at each of the 16 Operable Units (OUs). As such, the TSP identifies potentially applicable technologies for remediating the types of wastes and waste matrices that may be common to more than one OU in addition to generating data required to evaluate and screen technologies and/or alternatives. Ultimately, the information obtained from the sitewide and specific OU treatability studies will provide data to support the final remedy selection and design process.

The TSP followed a process of identifying potentially applicable technologies based on a literature/data base search and review of other available information. The potentially applicable technologies were evaluated in a two-step screening process. The preliminary screening identified those technologies suitable for application at Rocky Flats. The final screening identified the technologies appropriate for consideration in the sitewide treatability testing.

This TSWP fulfills the Stages 2 and 3 DQO process. The following discussion describes specific elements addressed in Stage 2, consistent with the Data Quality Objectives for Remedial Response Activities (EPA, 1987). These elements include:

- Data uses
- Data types
- Data quality needs
- Data quantity needs

- Sampling/analysis options

- Precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters

4.2 STAGE 2—IDENTIFYING DATA USES/NEEDS

Stage 2 of the DQO process defines data uses and specifies the data types needed to meet the project objectives. As noted above, the DQOs presented reflect the treatability studies screened in Stage 1. Table 4-1 describes the data needed to fulfill the specific objectives for the oxidation/ reduction treatability studies, the type of activity used to collect the data, the analytical level, and the intended data use.

4.2.1 Identifying Data Uses

Data uses for the Stage 2 Treatability Studies include:

- For the treatability influent, determining the original concentrations of the CLP target analyte list (TAL) match, radionuclides, and water quality parameters. The concentrations of the water quality parameters are used for calculating the dosage stoichiometry only. These parameters will not be tracked in the effluents.

- For oxidation/precipitation, optimizing coagulant dosage and determining operating pH to assess treatment effectiveness for the FS/CMSs

- For reduction, optimizing reducing agent dosage and determining operating pH to assess reduction effectiveness for the FS/CMSs

- For coprecipitation processes, optimizing polymer dosage and pH to assess treatment effectiveness for the FS/CMSs

TABLE 4-1

DATA NEEDS TO FULFILL SPECIFIC OBJECTIVES FOR REDOX TREATABILITY STUDIES

Treatability Influent	
Data Need:	Establish influent concentrations for a composite groundwater/surface water sample before initiating the treatability study.
Activity:	Collect representative samples from the two selected groundwater and surface water location. Composite the samples using flow-proportioned amounts. Filter the composite and analyze.
DQO Levels:	Metals, and Radionuclides–Level IV Cr (VI)–Level III Water Quality Parameters–Level III
Data Use:	Use the data in calculating the performance or removal efficiency for the individual treatability step
Reduction	
Data Need:	Evaluate the effectiveness of three different reducing agents for removing metals and radionuclides from surface water and groundwater at different dosages. In addition, evaluate the effectiveness of the reduction process by using alum, ferric chloride, or nothing as a coprecipitation agent.
Activity:	Conduct small laboratory scale multiple jar tests. Evaluate stannous chloride, sodium bisulfite, and ferrous sulfate as reducing agents for targeted metals and radionuclides. Evaluate the effect of pH on the efficiency of the process. Test the effectiveness of alum and ferric chloride as coprecipitation agents. Visually observe and measure precipitate settling rate.
DQO Levels: (Refer to Table 4-2 in this document)	Electrical Conductivity (EC) and pH–Level II Reagent and coagulant dose–Level II Precipitate formation and settling–Level II Metals and radionuclides–Level IV
Data Use:	Optimize reagent dosage and determine relative effectiveness of different reducing agents for removing targeted metals and radionuclides. Determine

TABLE 4-1

DATA NEEDS TO FULFILL SPECIFIC OBJECTIVES FOR REDOX TREATABILITY STUDIES (Continued)

	relative effectiveness of the reduction process without precipitation and the effectiveness of varying pH. Determine relative effectiveness of alum and ferric chloride as coprecipitation agents on samples which have been treated with highest dosage of stannous chloride reducing agent. Use this data to assess effectiveness of the tested reducing agents for FS/CMSs.
Precipitation/Coprecipitation	
Data Need:	Evaluate effectiveness of barium chloride, lime, alum, and ferric chloride, for removing metals and radionuclides for surface water and groundwater by standalone precipitation/coprecipitation processes.
Activity:	Conduct small laboratory scale multiple jar tests. Optimize pH, polymer type and dosage, and reagent dosage relative to metals and radionuclides removals. Visually observe and measure precipitate settling rate. Determine if precipitation/coprecipitation is effective in removing targeted metals and radionuclides without being proceeded by a Redox process.
DQO Levels: (Refer to Table 4-2 in this document)	EC and pH–Level II Reagent and coagulant dose–Level II Precipitate formation and settling–Level II Metals and radionuclides–Level IV
Data Use:	Optimize reagent dose, polymer coagulant type and dose, and pH. Use this date to assess the effectiveness of the tested processes for metals and radionuclides removal for FS/CMSs.
Oxidation	
Data Need:	Evaluate the effectiveness of the air oxidation process for removing iron and manganese from surface water and groundwater.
Activity:	Conduct small laboratory scale tests using multiple jar tests. Evaluate the effect of pH on the efficiency of the process. Visually observe and measure precipitate settling rate.

TABLE 4-1

DATA NEEDS TO FULFILL SPECIFIC OBJECTIVES FOR REDOX TREATABILITY STUDIES (Concluded)

DQO Levels: (Refer to Table 4-2 of this document)	EC and pH–Level II Precipitate formation and settling–Level II Metals (Fe and Mn)–Level IV
Data Use:	Optimize pH and assess effectiveness of air oxidation for iron and manganese removal for FS/CMSs.

4.2.2 Identifying Data Types

Data types include both analytical results to assess treatment effectiveness and qualitative judgements. Both oxidation/precipitation and reduction studies will generate analytical data measuring:

- pH
- Coagulant residuals
- Analytical data measuring concentrations of metals and radionuclides in the process decant
- Physical measurements (volumetric, weight) will be made to establish the administered reagent dosages

An oxidation and precipitation effectiveness evaluation also relies on a visual assessment and physical measurement of the rate of precipitate formation and settling.

4.2.3 Identifying Data Quality and Quantity Needs

EPA defines five levels of analytical data (EPA, 1987 modified) associated with data quality for treatability studies. The analytical levels correspond with those noted in Table 4-1.

- **Level I**—Field screening or analysis with portable instruments. This level provides an indication of contamination presence and has few QA/QC requirements.
- **Level II**—Field analyses with more sophisticated portable instruments or mobile laboratory. The data quality associated with this level depends on the QA/QC steps used. Data concentrations are usually reported in concentration ranges.

- **Level III**—Analyses of organics and inorganics are performed in an offsite analytical laboratory that may or may not involve contract laboratory program (CLP) procedures. The detection limits will be similar to those specified by the CLP. Level III uses rigorous QA/QC.

- **Level IV**—Analyses encompass the hazardous substance list (HSL) organic and inorganic parameters by sophisticated laboratory instrumentation such as gas chromatography/mass spectroscopy (GC/MS), atomic absorption (AA), and inductively coupled plasma (ICP). Detection limits reach the low parts-per-billion levels. This analytical level also provides tentative identification of non-HSL parameters. Data require validation to evaluate compliance with rigorous QA/QC requirements. Level IV procedures are appropriate to develop data of known quality.

  Note: The radionuclides analyses would generally be considered Level V because they are not "CLP" analyses; however, the level of QA/QC included in the EG&G Rocky Flats GRRASP Version 2.1 (DOE, 1991) is equivalent to that of "CLP" analyses. As such, the radionuclide analyses are considered to meet the Level IV data requirements.

- **Level V**—Analyses using nonstandard analytical methods. Method development or method modification may be required for specific constituents or detection limits.

Table 4-1 specifies the appropriate analytical levels for the data needs and data uses described in the table. Stage 2 treatability studies typically rely on Levels II through IV as reflected in Table 4-1.

Section 5.0 of this report describes the rationale for sampling frequencies and quantities for the oxidation/precipitation, reduction/precipitation, and precipitation/coprecipitation treatability studies.

4.2.4 Evaluating Sampling/Analysis Options

Data collection activities must be designed to obtain maximum use of the data. The sampling/analysis approach for these treatability studies is based on guidelines provided in the Treatability Studies Plan. If treatability results indicate that additional analyses or sampling are necessary, modifications will be made to the sampling analysis program. This will be done to avoid performing additional, redundant studies. Section 5.0 describes the sampling/analysis options in more detail.

4.2.5 Reviewing PARCC Parameter Information

PARCC (precision, accuracy, representativeness, completeness, comparability) parameters are indicators of data quality. Precision, accuracy, and completeness goals consider the analyses to be performed and the required analytical levels. Criteria established to meet PARCC requirements will be used to evaluate the data useability for data collected as part of the treatability study.

Appendix A of this document describes the analytical requirements for the treatability study. The analytical program specifies the use of analytical methods referenced in the EG&G Rocky Flats General Radiochemistry and Routine Analytical Services Protocol (GRRASP, Version 2.1) (DOE, 1991) for all analytes. These analytical methods are appropriate for meeting the data quality requirements for analytical levels II through V. The precision, accuracy, and completeness parameters for analytical levels II through V are discussed below along with the comparability and representativeness for all analytical levels. The DQOs specified for the precision, accuracy, and completeness will be used in evaluating the quality and useability of the laboratory data.

Precision and accuracy objectives for the treatability studies data will be evaluated based on the control limits specified in the referenced analytical method and/or in data validation guidelines. For the radionuclide analyses, the accuracy objectives specified in the GRRASP will be followed. The specified criteria for precision and accuracy summarized in Subsection 4.4.

For each sample taken and analysis performed in the treatability study, the objective for achieving useable data points is 90 percent.

Comparability is a qualitative parameter that expresses the confidence with which one data set can be compared with another. In order to achieve comparability, work performed as part of the treatability studies will follow approved sampling and analysis plans, use standardized analytical protocols, collect data following Environmental Management Department Operating Procedures (EMD OPs), and report data in consistent units of measurement.

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. It is a qualitative parameter that is most concerned with the proper design of the sampling program. The Sampling Plan described in Appendix A of this document and the referenced EMD OPS describe the rationale for the sample program to provide for representative samples. In designing the treatability studies, statistical considerations were evaluated in selection of sample numbers.

4.3 STAGE 3–DESIGN DATA COLLECTION PROGRAM

The Stage 3 DQO process includes discussions of the following elements, consistent with Data Quality Objectives for Remedial Response Activities (EPA, 1987):

- Data collection components
- Sampling and analysis plan

To accomplish this, the elements identified in Stages 1 and 2 were assembled and the Sampling Plan (Appendix A of this document) was prepared. Analyses are indicated in Section 5.0, Table 5-1. A detailed discussion of all samples to be collected is presented in Appendix A including sample type, number of samples, analytical methods, and QA/QC samples.

4.4 SUMMARY OF DATA QUALITY OBJECTIVES

Table 4-2 presents the QA/QC criteria for the Levels III and IV laboratory analyses proposed for the treatability study. No specific criteria are set for electrical conductivity and pH measurements other than multiple readings and those procedures prescribed by the instrument manufacturer. Reagent dosages primarily involve physical measurements of the volume and/or weights. Standard laboratory scales and volumetric devices are used for this purpose. Other than "good laboratory practices," no specific criteria are set for physical measurements. The weights and volumes will be estimated using the correct stoichiometry and the calculations will be double-checked for accuracy. Precipitate formation and settling primarily involve visual observations, and again, no DQOs are set for these. The water quality parameters are to be determined only for the treatability influent for calculating the dosages. These analyses will be performed consistent with the Level III goals.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA

Analyses	Frequency of QA/QC	QA/QC Criteria
TAL METALS:		
Initial Calibration	Daily (once every 24 hours).	ICP[a]: A blank and a minimum of one standard in proper operating range GFAA[b]: A blank and three standards in proper operating range. CVA[c]: A blank and four standards
Initial Calibration Verification (ICV)	Immediately after the initial calibration.	The measured value must be within 90 to 110 percent of the true value.
Continuing Calibration Verification (CCV)	Once every 10 samples or 2 hours; also at the beginning and the end of the sample run.	The measured value must be within 90 to 110 percent of the true value.
Contract Required Detection Limit (CRDL) Standard	A minimum of twice per 8 hours or at the beginning and the end of the sample run.	ICP[a]: At two times the CRDL or Initial Detection Limit (IDL); whichever is greater. Report the data. GFAA[b]: At CRDL or IDL;whichever is greater. Report the data.

[a]ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.
[b]GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.
[c]CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.
[d]Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.
[e]Water quality parameters include Cl, NO_2/NO_3, NO_3, SO_4, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.
[f]There should be no more than 20 samples per group; samples can be grouped in less than 20 items.
[g]Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Initial Calibration Blank (ICB)	Immediately after ICV, and once every 10 samples or 2 hours; also at the beginning and the end of the sample run.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the 10 samples prior to the noncompliant blank.
Continuing Calibration Blank (CCB)	Immediately after ICB, and once every 10 samples or 2 hours; also at the beginning and the end of the sample run.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the 10 samples prior to the noncompliant blank.
Preparation Blank (PB)	Once per 20 samples, a group[f] of samples, or 14 days, whichever is most frequent.	The blank concentrations must be below CRDL or the lowest sample concentration must be at least 10 times the blank concentration. Otherwise, redigest and reanalyze all samples.
ICP[a] Interference Check Sample (ICS)	At the beginning and the end of a sample run, or twice per 8 hours.	The ICS results must be within 80 to 120 percent of the true value.

[a]ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.
[b]GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.
[c]CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.
[d]Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.
[e]Water quality parameters include Cl, NO_2/NO_3, NO_3, SO_4, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.
[f]There should be no more than 20 samples per group; samples can be grouped in less than 20 items.
[g]Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Matrix Spike	Once per 20 samples, group of samples, or 14 days—whichever is most frequent.	The spiked sample results (after subtracting the original sample result) must be within 75 to 125 percent of the spiked value for sample concentrations, not exceeding four times the spike concentration. A post-digestion spike is required for ICP analyses if the spike criteria are not met.
Post Digestion Spike	In the event the matrix spike criteria are not met, once per 20 samples, group of samples, or 14 days—whichever is most frequent.	Spike the digestate at two times the sample level or the CRDL, whichever is greater. Report the data.
Duplicate Analysis	Once per 20 samples, group of samples, or 14 days' group—whichever is most frequent.	The relative percent difference (RPD) for sample concentrations greater than five times the CRDL must be within 20 percent for the duplicate pair. For concentrations below five times the CRDL, the duplicate results must be within +/-CRDL of the original value.

[a]ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.
[b]GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.
[c]CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.
[d]Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.
[e]Water quality parameters include Cl, NO_2/NO_3, NO_3, SO_4, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.
[f]There should be no more than 20 samples per group; samples can be grouped in less than 20 items.
[g]Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Laboratory Control Sample (LCS)	Once per 20 samples, group of samples, or 14 days' group–whichever is most frequent.	The LCS results must be within 80 to 120 percent of the true value. Otherwise, the samples must be redigested and reanalyzed.
ICP[a] Serial Dilution	Once per 20 samples, group of samples, or 14 days' group–whichever is most frequent.	For sample concentrations above 50 times the IDL, the serially diluted results must be within 90 to 110 percent of the original sample concentrations.
Instrument Detection Limit	Once every 3 calendar months.	IDL is calculated as three times the standard deviation of seven consecutive determinations per day for 3 nonconsecutive days (a total of 21 measurements). The IDLs must meet or exceed the CRDLs.
ICP[a] Interelement Correction Factors	Once every year, or after major instrument adjustments.	Report the factors.

[a]ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.
[b]GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.
[c]CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.
[d]Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.
[e]Water quality parameters include Cl, NO_2/NO_3, NO_3, SO_4, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.
[f]There should be no more than 20 samples per group; samples can be grouped in less than 20 items.
[g]Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
ICP[a] Linear Range	Once every 3 months.	The linear range standard must measure between 95 to 105 percent of the true value. Sample results cannot be reported beyond this value.
Standard Addition (GFAA)[b]	As required by the GFAA analytical scheme in the CLP Statement of Work (SOW).	The analytical spike recovery must be between 85 to 115 percent of the spiked amount. If not, samples with absorbance greater than 50 percent of the spiked sample absorbance must be analyzed by addition of three levels of standards. The coefficient of variance for the standard addition results must be 0.995 or better.
RADIONUCLIDES:[d]		
Instrument Background	Once every month.	Count for a minimum of 12 hours, and report.
Instrument Calibration	Once every week.	Report the data.
Efficiency Check Standards	Once every week.	Counted until 2,000 counts[g] (units of measure) recorded.

[a]ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.
[b]GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.
[c]CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.
[d]Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.
[e]Water quality parameters include Cl, NO_2/NO_3, NO_3, SO_4, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.
[f]There should be no more than 20 samples per group; samples can be grouped in less than 20 items.
[g]Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Laboratory Control Sample	Once per 20 samples, group of samples, or 14 days' group–whichever is most frequent.	Prepare and count the same as the samples. The measured value must be within three standard deviations of the true value, and the relative percent error not to exceed 10 percent. For tritium, gross alpha, and gross beta activities, the relative percent error must not exceed 15 percent.
Duplicate Sample	Once per 10 samples, group of samples, or 14 days' group–whichever is most frequent.	Prepare and count the same as the samples. The measured value must be within three standard deviations of the weighted average and its associated standard error.
Preparation Blank	Once per 20 samples, group of samples, or 14 days' group–whichever is most frequent.	Prepare and count the same as the samples. Report the data.
Minimum Detectable Activities (MDAs)	All samples.	The count duration should be optimized so that the required method detection limits are achieved.

[a]ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.
[b]GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.
[c]CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.
[d]Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.
[e]Water quality parameters include Cl, NO_2/NO_3, NO_3, SO_4, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.
[f]There should be no more than 20 samples per group; samples can be grouped in less than 20 items.
[g]Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Chemical Recovery	All samples.	Recovery for uranium isotopes must be within 30 to 105 percent. Recoveries for plutonium and americium isotopes must be within 20 to 105 percent.
WATER QUALITY PARAMETERS:[e]		
Instrument Calibration	Daily (once every 24 hours).	One blank and at least three standards in the proper operating range. The correlation coefficient must be 0.995 or greater.
ICV	Immediately after the initial calibration.	The ICV must be within 85 to 115 percent of the true value.
CCV	Immediately after the initial calibration.	The CCV must be within 85 to 115 percent of the true value.
ICB	Immediately after ICV, and before the samples.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the samples prior to the noncompliant blank.

[a]ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.
[b]GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.
[c]CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.
[d]Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.
[e]Water quality parameters include Cl, NO_2/NO_3, NO_3, SO_4, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.
[f]There should be no more than 20 samples per group; samples can be grouped in less than 20 items.
[g]Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
CCB	Immediately after ICB, and once every 20 samples; also at the end of the sample run.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the samples prior to the noncompliant blank.
PB	If applicable to the method, once per 20 samples, group of samples, or 14 days–whichever is most frequent.	The blank concentrations must be below CRDL, or the lowest sample concentration must be at least five times the blank concentration. Otherwise, redigest and reanalyze all samples.
LCS	Once every 20 samples, group of samples, or 14 days–whichever is most frequent.	The LCS recoveries must be within 80 to 120 percent of the true value.
Duplicate Sample	Once every 20 samples, a group of samples, or 14 days–whichever is most frequent.	The relative percent difference (RPD) between the duplicate pair must not exceed 20 percent.

[a]ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.
[b]GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.
[c]CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.
[d]Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.
[e]Water quality parameters include Cl, NO_2/NO_3, NO_3, SO_4, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.
[f]There should be no more than 20 samples per group; samples can be grouped in less than 20 items.
[g]Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
(Concluded)

Analyses	Frequency of QA/QC	QA/QC Criteria
Matrix Spike	Once every 20 samples, group of samples, or 14 days—whichever is most frequent.	Matrix spike recoveries must be within 75 to 125 percent for the samples with concentrations not exceeding four times the spike concentration

[a]ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.
[b]GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.
[c]CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.
[d]Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.
[e]Water quality parameters include Cl, NO_2/NO_3, NO_3, SO_4, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.
[f]There should be no more than 20 samples per group; samples can be grouped in less than 20 items.
[g]Counts = Unit of radioactive measure.

5.0 EXPERIMENT DESIGN AND PROCEDURES

This section describes the general approach and the detailed procedures to be followed in performing the Treatability Study. The procedures listed are the minimum number of experimental tasks to be preformed. When experimental results indicate the need for refinement/optimization of a particular experimental step during the course of the Treatability Study, additional experiments should be undertaken as described in Subsection 5.3 below. The field sampling locations are identified in Appendix A. The appropriate facility for performing the treatability tests is a water treatment laboratory performing chemical engineering reaction studies.

5.1 GENERAL OBJECTIVES

The general objective of the following test plan is to test the effectiveness of oxidation, reduction, precipitation, coprecipitation, and combinations of these reactions for removing metal and radionuclide contaminants from surface water and groundwater.

The treatability study will be conducted as a screening test which combines both qualitative and quantitative tests for evaluating processes for the removal of metals and radionuclides. Tasks 2 through 9 below describe the screening tests in detail.

5.2 KEY ASSUMPTIONS

Several assumptions were made in selecting treatment processes and specifying test conditions for evaluation in the laboratory. These are:

- The principal (or only) process by which some of the low-level constituents can be removed involves coprecipitation.

- Neither oxidation nor reduction is used alone; either must be accompanied by some type of precipitation process.

- A field of four reduction reactions, seven precipitation reactions, and three oxidation reactions were identified for possible consideration and are shown in Figure 5-1.

- The treatment reactions that were selected from Figure 5-1 for screening in the laboratory were organized into four groups. These four groups were arranged into a sequence of process steps that are possible to implement in a full-scale water treatment facility (see Figure 5-2).

- The criteria for treatment effectiveness are the removal efficiencies for the inorganic species, and the precipitate coagulation characteristics of the various reagents. The types of chemical analyses and settling tests to be performed at each test condition are summarized in Figure 5-3.

- The primary parameters affecting a reducing agent are pH, reagent dosage (redox potential), reaction time, and temperature for the current tests. A temperature range between 15° and 25°C and a 30-minute batch reaction time have been taken as the reference case, based on the kinetics of similar redox reactions (Patterson, 1985). Consequently, only pH, reductant dosage (redox potential), and choice of final coagulant are variables.

- Nominal reductant requirements were estimated from maximum concentrations of reducible species, plus 10 mg/L of dissolved oxygen. Redox potential is a useful surrogate parameter for monitoring the sufficiency of reducing agent dosages. The low reductant dosage is approximately 20 percent excess (120 percent of the nominal requirement) and the high dosage represents approximately 300 percent excess (400 percent of the nominal requirement).

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Contaminant Type

	Al	Sb	As	Ba	Be	Cd	Cr	Fe	Pb	Mn	Hg	Ni	Se	Pu	Ra	U
A. Reduction																
1. Stannous Chloride							○				●		○	●		○
2. Ferrous Salt							●						●	●		○
3. Sulfite							●						○	●		○
4. Acidic Iron													●	○		○
B. Precipitation																
1. Lime	●	○	●		○	●	●	●	●	●	○	●				
2. Alum		○	●		○									○		●
3. Ferric Salt		○	●		○	●	●		●			○	●	○		○
4. Phosphate	●						●	●	●					○		●
5. Barium Chloride/Sodium Sulfate				●											●	
6. Lime/Sulfide						●			●		●	●				
C. Oxidation																
1. Air/Oxygen								●		○						
2. Hypochlorite								●								
3. Potassium Permanganate								●		●						

● Target Constituent
○ Potentially Effective

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Figure 5-1
MATRIX OF RELATIONSHIPS BETWEEN METALLIC CONTAMINANTS AND TREATMENT PROCESS REACTIONS

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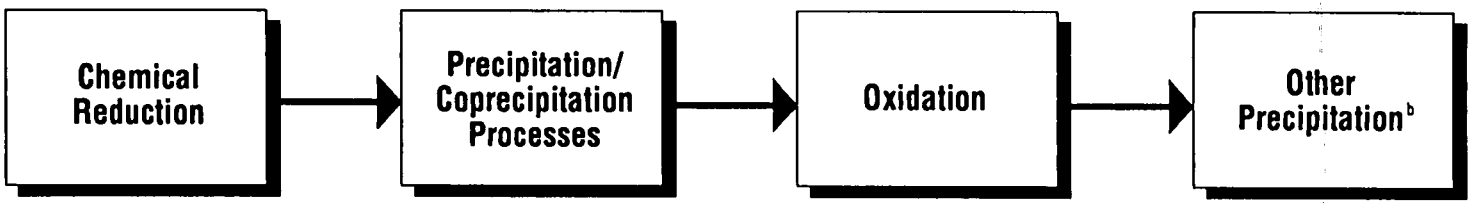

Expected Efficiency of the Processes [a]

1 - Ferrous Sulfate	1 - Ferric Chloride	1 - Air	1 - Lime
2 - Sodium Bisulfite	2 - Alum		
3 - Stannous Chloride	3 - Barium Sulfate ($BaCl_2 + Na_2 SO_4$)		

a - For example, it is expected that the use of ferrous sulfate will be the most efficient additive for the chemical reduction stage.

b - Additional precipitation may be required for achieving metal removal.

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Figure 5-2
PREFERRED TREATMENT SEQUENCE FOR METAL CONTAMINANT REMOVAL BY REDUCTION/OXIDATION/PRECIPITATION PROCESSES

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I. CHEMICAL REDUCTION		ANALYSES	
Reducing Agent[1]	**Precipitant System**[2]	**Required**	**Supplemental**
Ferrous Sulfate	→ Lime @ pH 9-9.5		
pH 5.0/7.5	→ Alum @ pH 5.5-6.5	Cr, Hg, Pu	Fe, Electrical Conductivity
$FeSO_4$ 290-950 mg/L	15 mg/L as $Al_2(SO_4)_3$	Cr, Hg, Pu	Redox Potential, Al, Se, U, pH
Redox Potential (est.)			
-0.59 to -0.44v			
Sodium Bisulfite	→ Lime @ pH 9-9.5	Cr, Hg, Pu	Electrical Conductivity
pH 2 - 3.5	→ Alum @ pH 5.5-6.5	Cr, Hg, Pu	Redox Potential, Al, Se, U, pH
$NaHSO_3$ 160-540 mg/L	15 mg/L as $Al_2(SO_4)_3$		
Redox Potential (est.)			
-0.097 to -0.067v		Cr, Hg, Pu	Sn, Electrical Conductivity
Stannous Chloride	→ Alum @ pH 5.5-6.5		Redox Potential, Al, Se, U, pH
pH (IM, HCl)	15 mg/L as $Al_2(SO_4)_3$	Cr, Hg, Pu	
$SnCl_2$ 295-980 mg/L	→ Ferric Chloride		
Redox Potential (est.)	@ pH 5.5-6.5, 15mg/L		
+0.11 to +0.16v			
II. BARIUM SULFATE COPRECIPITATION			
Precipitants[1]			
$BaCl_2$ 25-50 mg/L	→ Ferric Chloride	Ra, Ba	Electrical Conductivity, pH
Na_2SO_4 0-75 mg/L[c]	@ pH >5, 15 mg/L		
pH 8-10			
III. PRECIPITATION			
Precipitant[1]	**Coagulant/Polymer**		
Lime as CaO			
pH 9-11	→ Anionic 0-1 mg/L	Al, Sb, As, Be, Cd, Fe, Pb, Mn, U, Ni, Solids Settling Rate	Pu, Hg, Cr
Ferric Chloride			
pH 5.5-10	→ Anionic 0-1 mg/L	Sb, As, Be, Cd, U, Fe,	
$FeCl_3$ 60 mg/L	→ Nonionic 0-2 mg/L	Pb, Mn, Ni, Se,	Pu, Cr
	→ Cationic 0-5 mg/L	Solids Settling Rate	
Alum			
pH 5.5-7.5	→ Anionic 0-1 mg/L	Sb, As, Be, U, Al,	Pu
$Al_2(SO_4)_3$ 60 mg/L	→ Nonionic 0-2 mg/L	Solids Settling Rate	
	→ Cationic 0-5 mg/L		
IV. OXIDATION			
Air Sparging		Fe, Mn	
pH 6.5-10			
Ferrous Iron (Fe)			

[1] As the anhydrous salt.
[2] Underlined system identifies base case precipitant.
[3] Sodium sulfate only added if sulfate concentration of sample is below 50 mg/L.

Figure 5-3
SCREENING SUMMARY OF REDUCING AGENTS, BARIUM SULFATE COPRECIPITATION, PRIMARY PRECIPITANTS, AND OXIDATION

- Ferrous iron becomes a more effective reducing agent as the pH increases, but upper limits to pH are imposed by increasing reaction with dissolved oxygen and the onset of precipitation above a pH of approximately 8.

- Sodium bisulfite (and related reagents) are more effective for chromium VI reduction at pH 2.0 than at pH 4.0, but below pH 2.0, the sulfur dioxide losses are excessive.

- Stannous chloride is used as a reducing agent at low pH because of the low solubility of stannous oxide at higher pH levels. Consequently, stannous chloride is used in one molar hydrochloric acid, and not at higher pH values.

- Barium has been reported effective in reducing residual radium concentrations to below 5 pCi/L, at a 16 mg/L Ba^{+2} dosage, followed by flocculation with ferric chloride (Averill, et al., 1981). If sufficient naturally occurring sulfate is present, only barium chloride and ferric chloride addition should be needed to reduce the radium level. A 30-minute residence time appears to be adequate for radium coprecipitation with barium sulfate.

It is expected that not all of the regulated constituents will be present in groundwater or surface water at concentrations above their regulated limits simultaneously. It is also unlikely that the optimum treatment conditions for all the target constituents can be maintained concurrently. Consequently, reagent dosages and redox potentials are only estimates and need to be adapted for actual sample compositions. There is redundancy among the four process groups that allows the process(es) most likely to be effective with the largest number of constituents to be selected as the first priority for testing. In addition, the tests will provide information to determine what minimum levels of contaminants can be treated.

5.3 TASK DESCRIPTIONS

The tasks summarized below in outline form describe the work to be performed. Each task corresponds to a flow-chart illustration (referred to in parentheses at the beginning of each task), which supplement the text description.

Tasks 2 through 9 will need to be performed (as described in this TSWP) on *each* of the four samples of groundwater and surface water described in the Sampling Plan included as Appendix A of this TSWP. All results are to be recorded on forms such as those shown in the Environmental Management Department Operating Procedures (EMD OPS) (EG&G, 1991).

The processes that are expected to remove the largest array of constituents and/or are expected to be most effective in achieving low residual metal concentrations will be tested first. If none of the priority processes are effective, then additional work on lower priority processes or further optimization of the first priority processes can be pursued at the discretion of the treatability study manager. Blank samples using distilled water will be used whenever there is a possibility of adding an identified contaminant to the treatment sample from reagent addition. All completed treatment samples will be filtered prior to analysis, in order to prevent the re-dissolving of any precipitates.

The first priority processes for each of the four groups are listed below in the order of expected efficiency. The target constituents are in parentheses. Those underlined are the primary target constituents.

- Reduction
  - Ferrous sulfate (chromium, mercury, plutonium, selenium, uranium)
  - Sodium bisulfite (chromium, mercury, plutonium, selenium, uranium)
  - Stannous chloride (chromium, mercury, plutonium, selenium, uranium)

- Coprecipitation
  - Iron (ferric) salts (antimony, arsenic, beryllium, cadmium, chromium, lead, nickel, selenium, plutonium, uranium)
  - Alum (antimony, arsenic, beryllium, plutonium, uranium)
  - Barium sulfate (radium)
- Oxidation
  - Air (iron, manganese)
- Other Precipitation
  - Lime (aluminum, antimony, arsenic, beryllium, cadmium, chromium, iron, lead, manganese, mercury, nickel)

Task 1a—Preparation

- Review and understand the test plan
- Verify that the materials, equipment, and chemical inventories shown in Section 6.0 of this document are available, and obtain any that are not on hand.
- Prepare stock solutions from the soluble reagents for use in the tests.
- Clean all containers using the following EPA-approved cleaning sequence:
  - **Glassware.** Using laboratory-grade detergent wash, rinse; rinse with HNO_3; deionized water wash and rinse; solvent rinse; oven dry; cap or cover.

- **Plasticware.** Same as glassware, but omit the solvent rinse.

- Calibrate all instruments according to manufacturer's instructions.

- Prepare acid and base titration curves of the treatment sample.

- Perform a complete chemical analysis of the filtered (0.45-micron pore size filter) treatment sample, including the concentrations of water quality parameters, heavy metals, and radionuclides. The filtrate analyses include antimony, arsenic, barium, beryllium, cadmium, chromium, iron, lead, manganese, mercury, nickel, selenium, aluminum, plutonium, radium, uranium, alkalinity, electrical conductivity, sodium, potassium, calcium, magnesium, chloride, sulfate, nitrate, and pH. No analysis of unfiltered samples will be preformed. All chemical analyses will follow strict criteria of the EG&G Rocky Flats GRRASP Version 2.1 (DOE, 1991).

Task 1b—General Instructions Applicable to Tasks 2 through 9

- Measure the temperature continuously during mixing. (This step applies to all aliquots and distilled water blanks.)

- Record the temperature, pH, and redox potential during mixing a minimum of three times. (This step applies to all aliquots and distilled water blanks.) The standard operating procedures to be used for pH, electrical conductivity, and oxidation/ reduction potential are the manufacturers' recommendations provided in the equipment instructions.

- The procedure to measure the settling rate will be visual observation using professional judgement. Physical measurement of the level of floc will be conducted if needed.

- Filter all samples (using a 0.45-micron pore size filter) immediately after testing, and before transporting to the laboratory for analysis.

- Adjust pH levels with either calcium hydroxide or hydrochloric acid, depending on whether the levels must be adjusted higher or lower.

Task 2–Ferrous Sulfate Reduction[1] (Figure 5-4)

- Adjust the pH of 200 mL sample aliquot(s) to pH 7.5, and prepare a redox titration curve by titrating with ferrous sulfate solution of known strength. Enough ferrous sulfate solution should be added to raise the concentration in the sample aliquot to at least 2,400 mg/L. Compare the observed reagent dosages and redox potentials with those estimated in the TSWP, and adjust the test conditions accordingly, relying mainly on titration curve and sample composition results.

Step 1:

- Place 4,000 mL of the sample into each of three 6-L beakers.

- Adjust the sample aliquots to pH 7.5. Treat with 290 mg/L (low-dose), 475 mg/L, and 950 mg/L (high-dose) of ferrous sulfate, respectively and mix for 30 minutes. The corresponding redox potentials are estimated to be -585, -503, and -447 mv (milivolts), respectively.

- Following the reaction, adjust the pH to 9.5 with calcium hydroxide, mix for approximately 10 minutes, then allow precipitation solids to settle for 10 minutes. Note appearance of solids and measure settling rate.

[1]Note that in conducting tasks, all reagent addition quantities are based on anhydrous formula weights. Hydrated reagents or equivalent compounds may be substituted if the appropriate adjustment in dosage is made.

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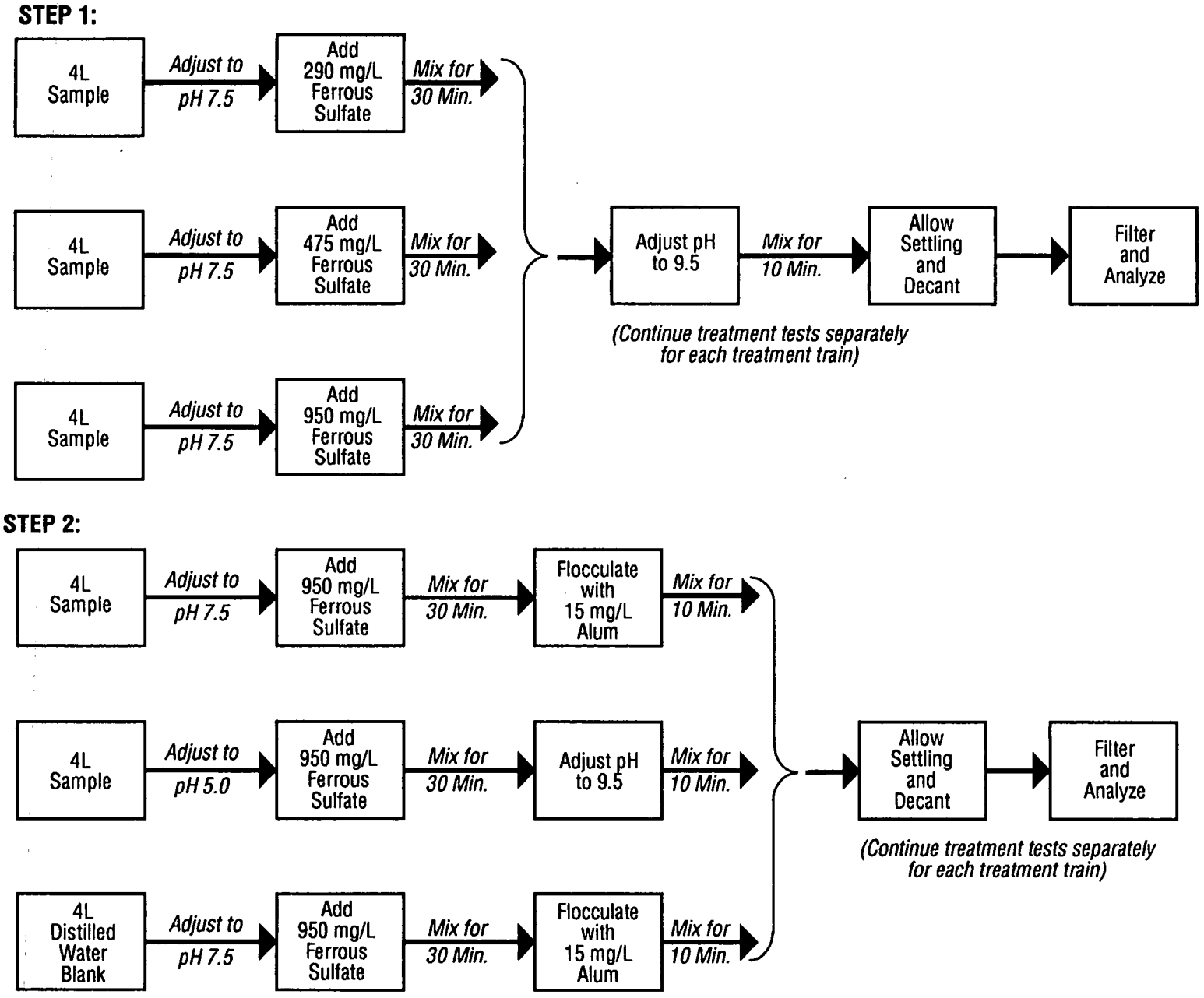

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Figure 5-4
TASK 2 - FERROUS SULFATE REDUCTION

- Decant clear liquid, filter through a 0.45 micron filter, and analyze for chromium, mercury, and plutonium.

- In the high-dose sample only, analyze for aluminum, iron, selenium, pH, redox potential, electrical conductivity, and uranium. Electrical conductivity is being measured to determine ionic strength and as an indirect measure of total dissolved solids (TDS).

Step 2:

- Place 4,000 mL of the sample into each of two 6-L beakers.

- Place 4,000 mL of distilled water into a 6-L beaker and adjust to pH 7.5 using calcium hydroxide, as needed.

- Adjust the pH of the treatment sample in the two beakers to 5.0 and 7.5, respectively. Add 950 mg/L of ferrous sulfate to the two treatment samples and the distilled water and mix for 30 minutes.

- Following the reaction, adjust the pH 5.0 sample to 9.5 with calcium hydroxide, mix for 10 minutes, settle the solids for 10 minutes, decant clear liquid, and prepare the filtered treated sample for analysis of chromium, mercury, and plutonium. Record appearance of settleable solids and measure the settling rate.

- For the pH 7.5 treatment sample and the distilled water, flocculate with 15 mg/L of alum (expressed as anhydrous aluminum sulfate), mix for 10 minutes, settle the solids, decant, and prepare a filtered sample and distilled water for analysis of chromium, mercury, plutonium, iron, aluminum, selenium, uranium, and electrical conductivity. Measure pH and redox potential.

- Observe and record sludge appearance, settled volumes, and other features.

Step 3:

- Dispose of liquid and solid treatment wastes in accordance with Section 9.0 of this TSWP.

Task 3–Sodium Bisulfite Reduction (Figure 5-5)

- Adjust the pH of 200 mL sample aliquot(s) to pH 2.0, and prepare a redox titration curve by titrating with sodium bisulfite solution of known strength. Enough sodium bisulfite solution should be added to raise the concentration in the sample aliquot to at least 2,700 mg/L. Compare the observed reagent dosages and redox potentials with those estimated in the TSWP, and adjust the test conditions accordingly, relying mainly on titration curve and sample composition results.

Step 1:

- Place 4,000 mL of sample into each of three 6-L beakers.

- Adjust the sample aliquots to pH 2.0, using hydrochloric acid. Treat with 160 mg/L, (low-dose), 270 mg/L, and 540 mg/L (high-dose) of sodium bisulfite, respectively, and mix for 30 minutes. The corresponding redox potentials are estimated to be -97, -77, and -63 mv, respectively.

- Following the reaction, add 15 mg/L of alum expressed as anhydrous aluminum sulfate in solution, adjust pH to 6.0, mix for 10 minutes, settle the solids for 10 minutes, decant, filter, and prepare treated samples for analysis of chromium, mercury, and plutonium.

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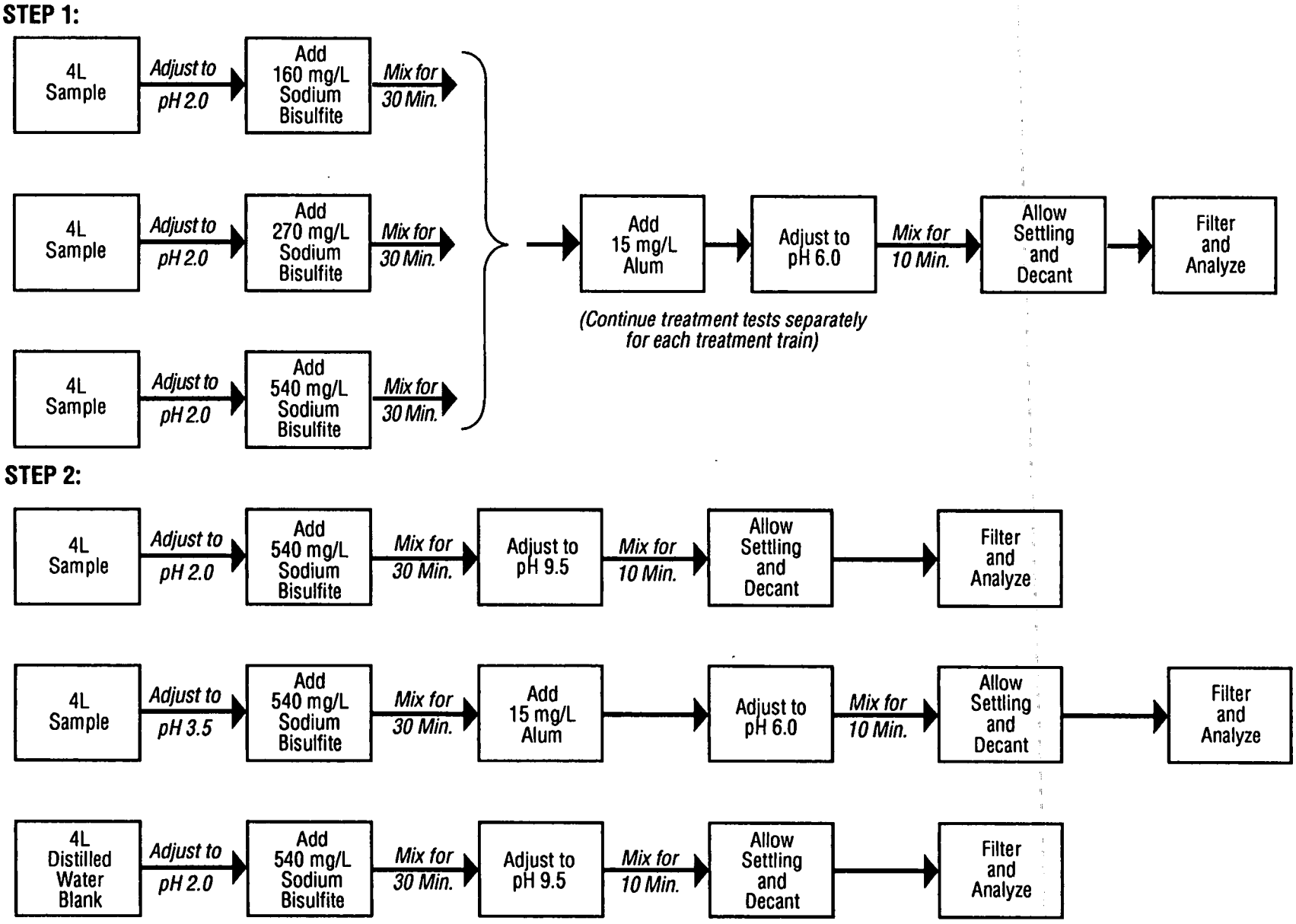

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Figure 5-5
TASK 3 - SODIUM BISULFITE REDUCTION

- In the high-dose sample, also analyze for aluminum, selenium, uranium, and electrical conductivity. Measure the redox potential and pH of the high-dose sample.

Step 2:

- Place 4,000 mL of sample into each of two 6-L beakers.
- Place 4,000 mL of distilled water into a 6-L beaker and adjust to pH 2.0, using hydrochloric acid.
- Adjust the pH of the treatment samples in the two beakers to 2.0 and 3.5, respectively, using hydrochloric acid. Add 540 mg/L of sodium bisulfite and mix both of the treatment samples and the distilled water for 30 minutes.
- Following the reaction, adjust the pH 2.0 sample and the distilled water to 9.5 with calcium hydroxide, mix for 10 minutes, settle the solids, decant, filter and analyze the treated sample and distilled water for chromium, mercury, plutonium, selenium, uranium, and electrical conductivity.
- To the pH 3.5 treatment sample, add 15 mg/L of alum expressed as anhydrous aluminum sulfate in solution, adjust to pH 6.0, mix for 10 minutes, settle the solids, decant, filter, and analyze the treated sample for chromium, mercury, and plutonium.
- Observe and record sludge appearance, settled volumes, and other features.

Step 3:

- Dispose of liquid and solid treatment wastes in accordance with Section 9.0 of this TSWP.

Task 4–Stannous Chloride Reduction (Figure 5-6)

- Adjust 200 mL sample aliquot(s) to 1 M (molar) strength with concentrated hydrochloric acid, and prepare a redox titration curve by titrating with stannous chloride solution of known strength. Enough stannous chloride solution should be added to raise the concentration in the sample aliquot to at least 2,500 mg/L. Compare the observed reagent dosages and redox potentials with those estimated in the TWSP, and adjust the test conditions accordingly, relying mainly on titration curve and sample composition results.

Step 1:

- Place 4,000 mL of sample into each of three 6-L beakers.
- Adjust the samples to 1 M (molar) in hydrochloric acid, treat with 295 mg/L (low-dose), 490 mg/L, and 980 mg/L (high-dose) of stannous chloride expressed as anhydrous salt in solution, respectively, and mix for 30 minutes. The corresponding redox potentials are estimated to be 108, 128, and 142 mv, respectively.
- Following the reaction, add 15 mg/L of alum, adjust to pH 6.0, mix for 10 minutes, settle the solids, decant, filter, and analyze the treated samples for chromium, mercury, and plutonium.
- In the high-dose sample, also analyze for aluminum, selenium, uranium, and electrical conductivity. Measure redox potential and pH.

Step 2:

- Place 4,000 mL of sample into a 6-L beaker.

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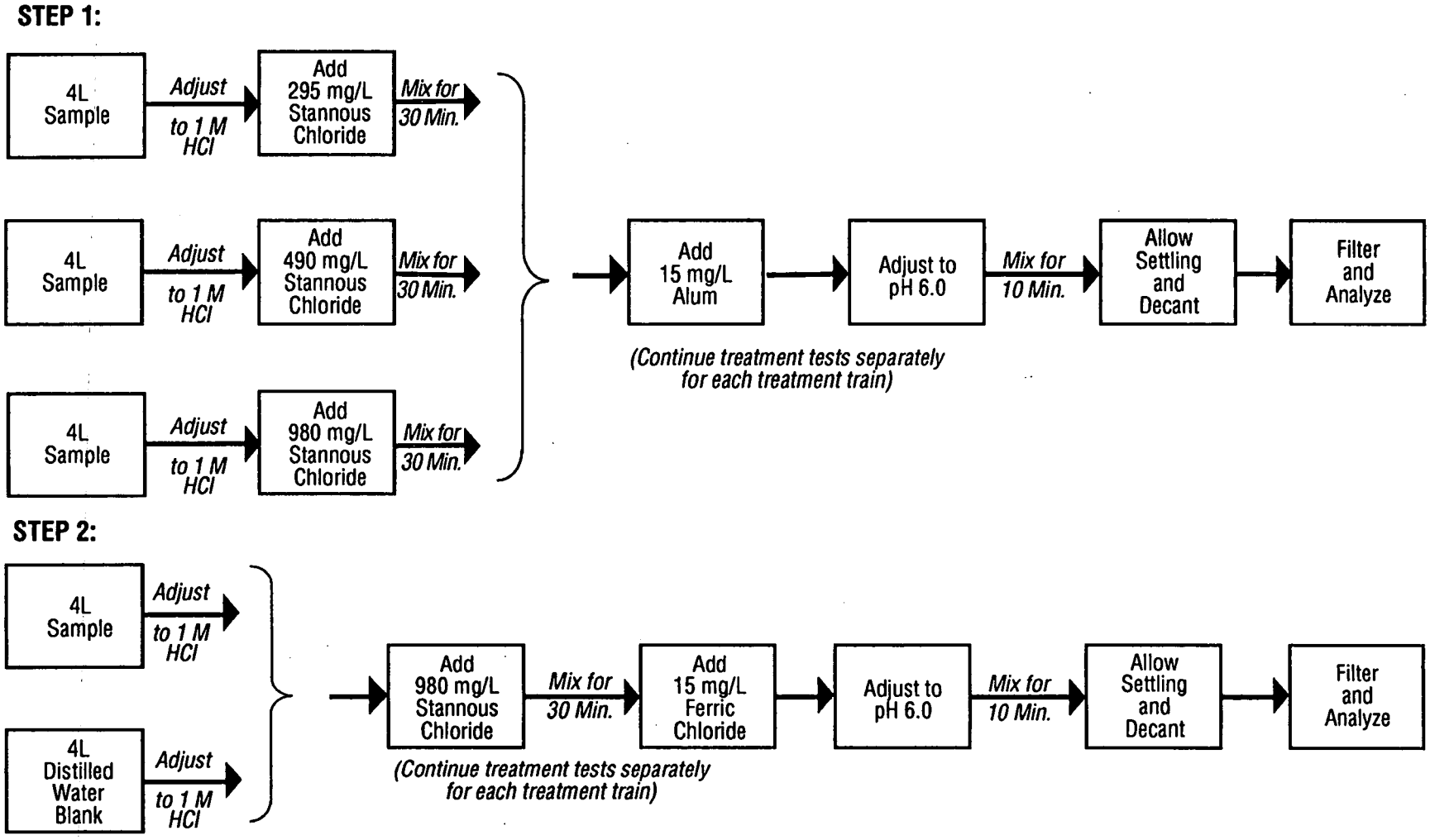

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Figure 5-6
TASK 4 - STANNOUS CHLORIDE REDUCTION

- Place 4,000 mL of distilled water into a beaker and adjust to 1 M in hydrochloric acid.

- Adjust the treatment sample to 1 M in hydrochloric acid. Add 980 mg/L of stannous chloride to both the treatment sample and the distilled water in solution, and mix for 30 minutes.

- Following the reaction, add 15 mg/L of ferric chloride, adjust to pH 6.0, mix 10 minutes, settle the solids, decant, filter, and analyze the treated sample and distilled water for chromium, mercury, plutonium, selenium, uranium, and electrical conductivity.

- Observe and record sludge appearance, settled volume, and other features.

Step 3:

- Dispose of liquid and solid treatment wastes in accordance with Section 9.0 of this TSWP.

Task 5—Barium Sulfate Coprecipitation (Figure 5-7)

Step 1:

- Place 2,000 mL of sample into each of two 4-L beakers and adjust the pH to 9.0. Add 25 mg/L (low-dose) and 50 mg/L (high-dose) of barium chloride respectively, and mix for 30 minutes. (If the sulfate concentration is below 50 mg/L, add 75 mg/L of sodium sulfate) immediately after the barium chloride is fully mixed.

- Following mixing, add 15 mg/L of ferric chloride expressed as anhydrous salt in solution, verify that the pH is above 5.0 (adjust with calcium hydroxide as

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Douville			12/13/91	RFP TSWP 1024A
12/09/91		APPROVED BY	12/13/91	

STEP 1:

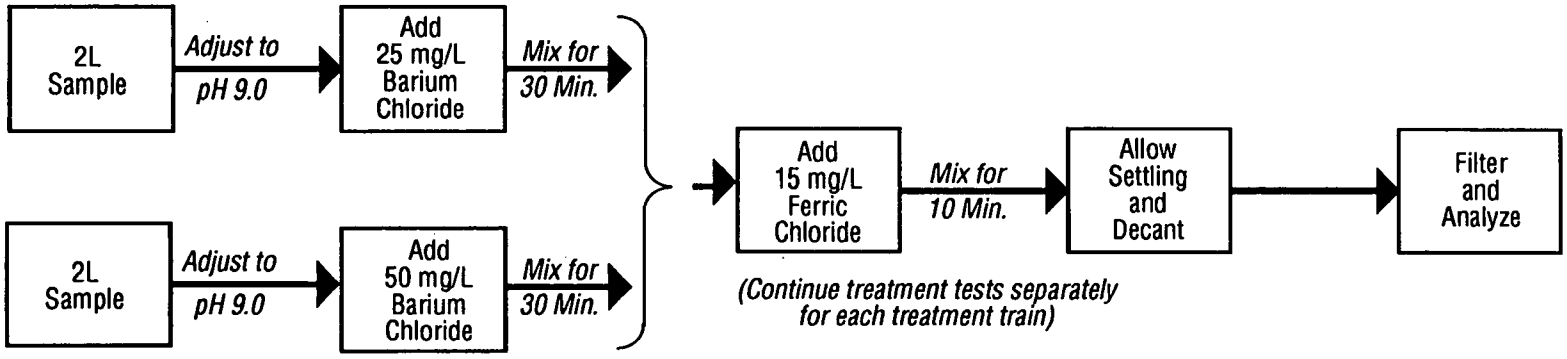

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Figure 5-7
TASK 5 - BARIUM SULFATE COPRECIPITATION

necessary), mix for 10 minutes, settle the solids, decant, filter, and analyze for radium and barium.

- Observe and record sludge appearance, settled solids, settling rate and other features.

Step 2:

- Dispose of liquid and solid treatment wastes separately in accordance with Section 9.0 of this TSWP.

Task 6—Lime Precipitation (Figure 5-8)

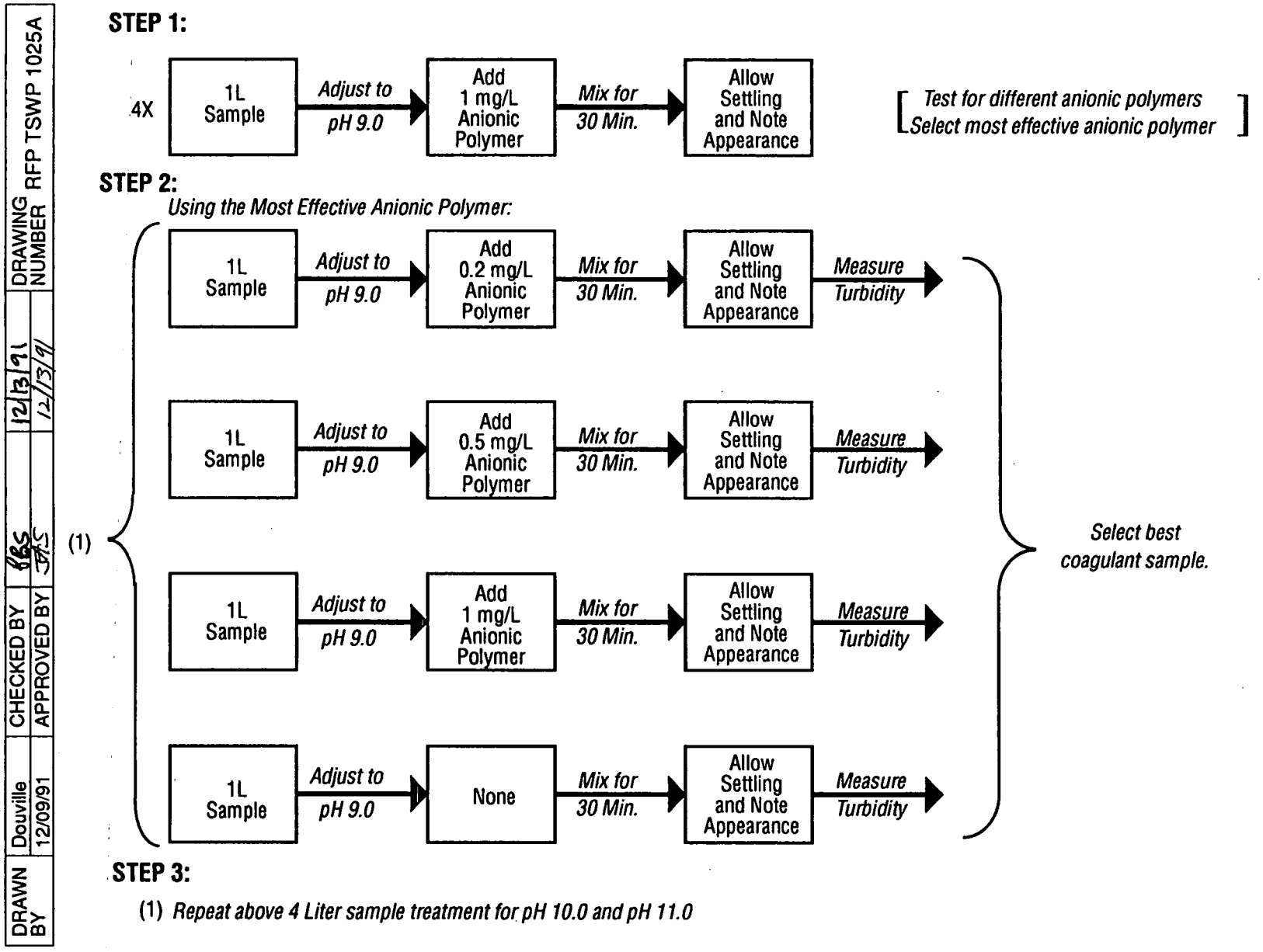
Step 1:

- Place 1,000 mL of sample into each of four 2-liter beakers, place them on the 6-paddle stirrer, adjust the pH to 9.0, and add 1 mg/L of a different anionic polymer to each sample. Table 6-2 refers to the different ionic polymers to be used in the treatability tests. The most effective polymer will be chosen by observing which causes the highest amount and setting rate of floc.

- Mix for 30 minutes, remove the stirrer paddles, allow the solids to settle, and note the appearance and settling rate of the floc (if any).

Step 2:

- Select the most effective anionic polymer for further tests in four fresh 1,000 mL sample aliquots (at the same pH), and dosages of 0.0 mg/L, 0.2 mg/L, 0.5 mg/L, and 1 mg/L of polymer. Compare the coagulated solids and note any differences. Measure the turbidity.



DEN30181.S1/12-09-91/HMD

Figure 5-8
TASK 6 - LIME PRECIPITATION

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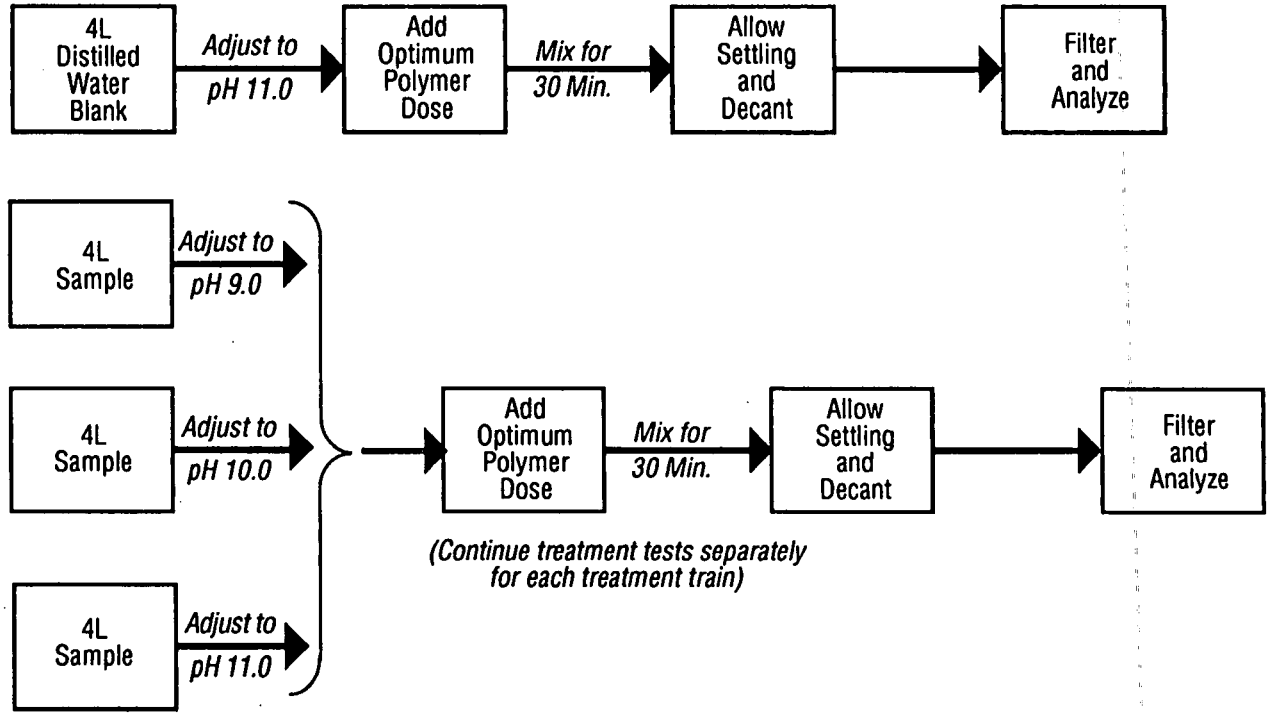
Douville 12/09/91	APPROVED BY	12/13/91		RFP TSWP 1026A

STEP 4:



DEN30181.S1/12-09-91/HMD

Figure 5-8
TASK 6 - LIME PRECIPITATION
(Concluded)

- Transfer the best coagulant sample to a 1-Liter graduated cylinder, record the settling rate and final volume of solids after 1 hour. Report the number of inches (or cm) the liquid/solid interface has advanced at 1/2 to 1 minute intervals for the first 5 to 10 minutes, and less frequently thereafter.

Step 3:

- Repeat Steps 1 and 2 at pH values of 10.0 and 11.0.

Step 4:

- Place 4,000 mL of distilled water into a beaker (6-L) and adjust the pH to 11.0 with calcium hydroxide.

- Place 4,000 mL of sample into each of three 6-L beakers and adjust the pH to 9.0, 10.0, and 11.0 with calcium hydroxide. Add the optimum polymer dose, and mix for 30 minutes (for the three samples and the distilled water).

- After mixing, settle the solids, decant, filter, and analyze for aluminum, antimony, arsenic, beryllium, cadmium, iron, lead, manganese, mercury, nickel, plutonium, and uranium.

Step 5:

- Dispose of liquid and solid treatment wastes in accordance with Section 9.0 of this TSWP.

Task 7—Iron Coprecipitation (Figure 5-9)

Step 1:

- Place 1,000 mL of sample into each of six beakers, place them on the 6-paddle stirrer, treat each with 60 mg/L of ferric chloride, and adjust the pH to 5.5 with calcium hydroxide. Add 5 mg/L of two different cationic polymer to two of the samples, 2 mg/L of two different nonionic polymers to two other samples, and 1 mg/L of two different anionic polymers to the final two samples.

- Mix for 30 minutes, remove the stirrer paddles, allow the solids to settle, and note the appearance and settling rate of the floc.

Step 2:

- Repeat Step 1 using the most effective polymer type with four fresh 1,000 mL sample aliquots, three at discrete polymer doses, plus one polymer-free control sample. The polymer dose progression should be in the following succession (depending on polymer choice):

  - Anionic—0.0 mg/L, 0.2 mg/L, 0.5 mg/L, 1 mg/L
  - Nonionic—0.0 mg/L, 0.5 mg/L, 1.0 mg/L, 2 mg/L
  - Cationic—0.0 mg/L, 1 mg/L, 2 mg/L, 5 mg/L

  Compare the coagulated solids and note the results. Measure the turbidity.

- Transfer the best-coagulated sample to a 1-L graduated cylinder, record the settling rate and final volume of solids after 1 hour. Report the number of inches (or cm) the liquid/solid interface has advanced at 1/2- to 1-minute intervals for the first 5 to 10 minutes, and less frequently thereafter.

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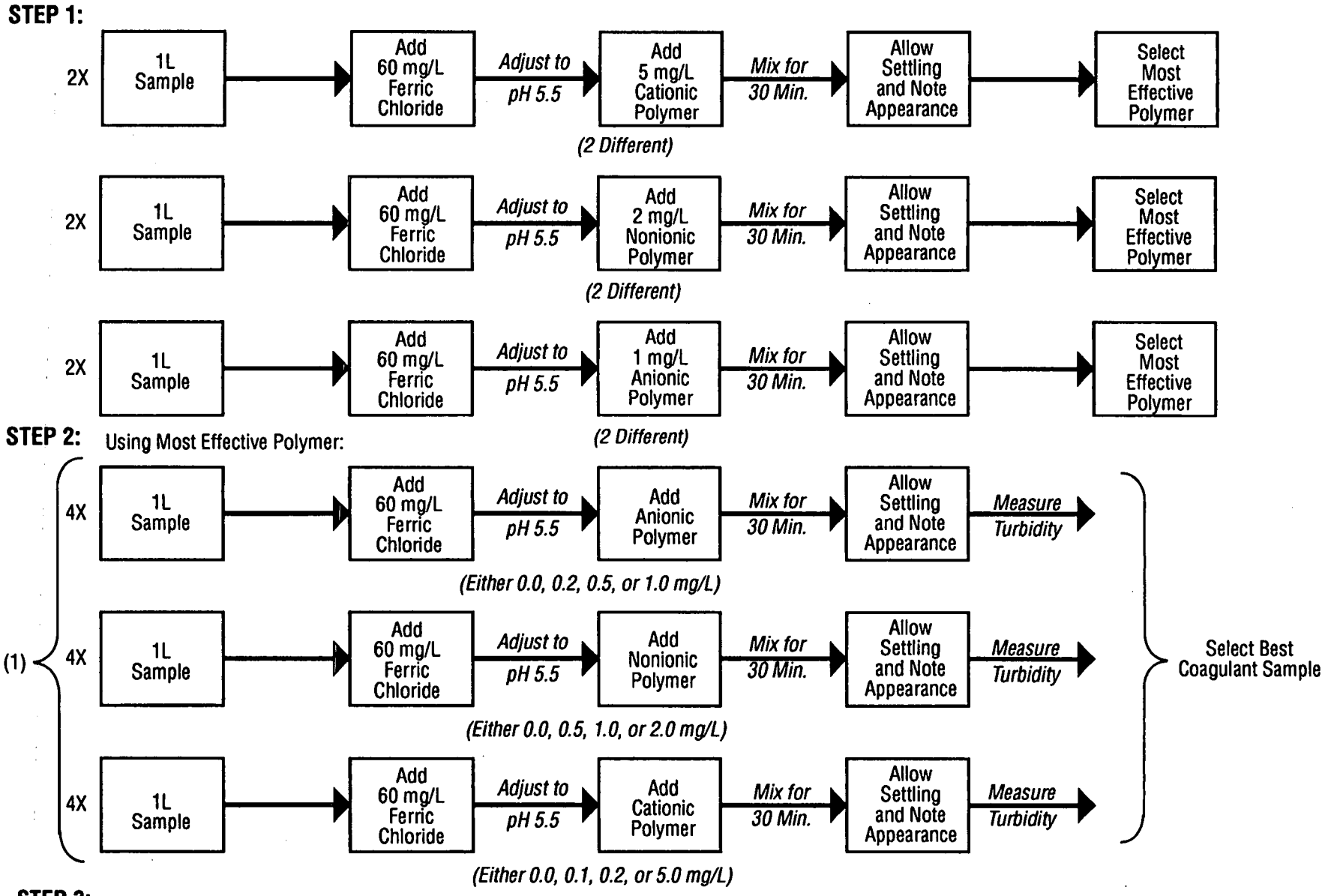

STEP 3:

(1) Repeat Above 12 Liter Samples Treatment for pH 8.0 and 10.0

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Figure 5-9
TASK 7 - IRON COPRECIPITATION

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	12/09/91	APPROVED BY	12/13/91		12/13/91

STEP 4:

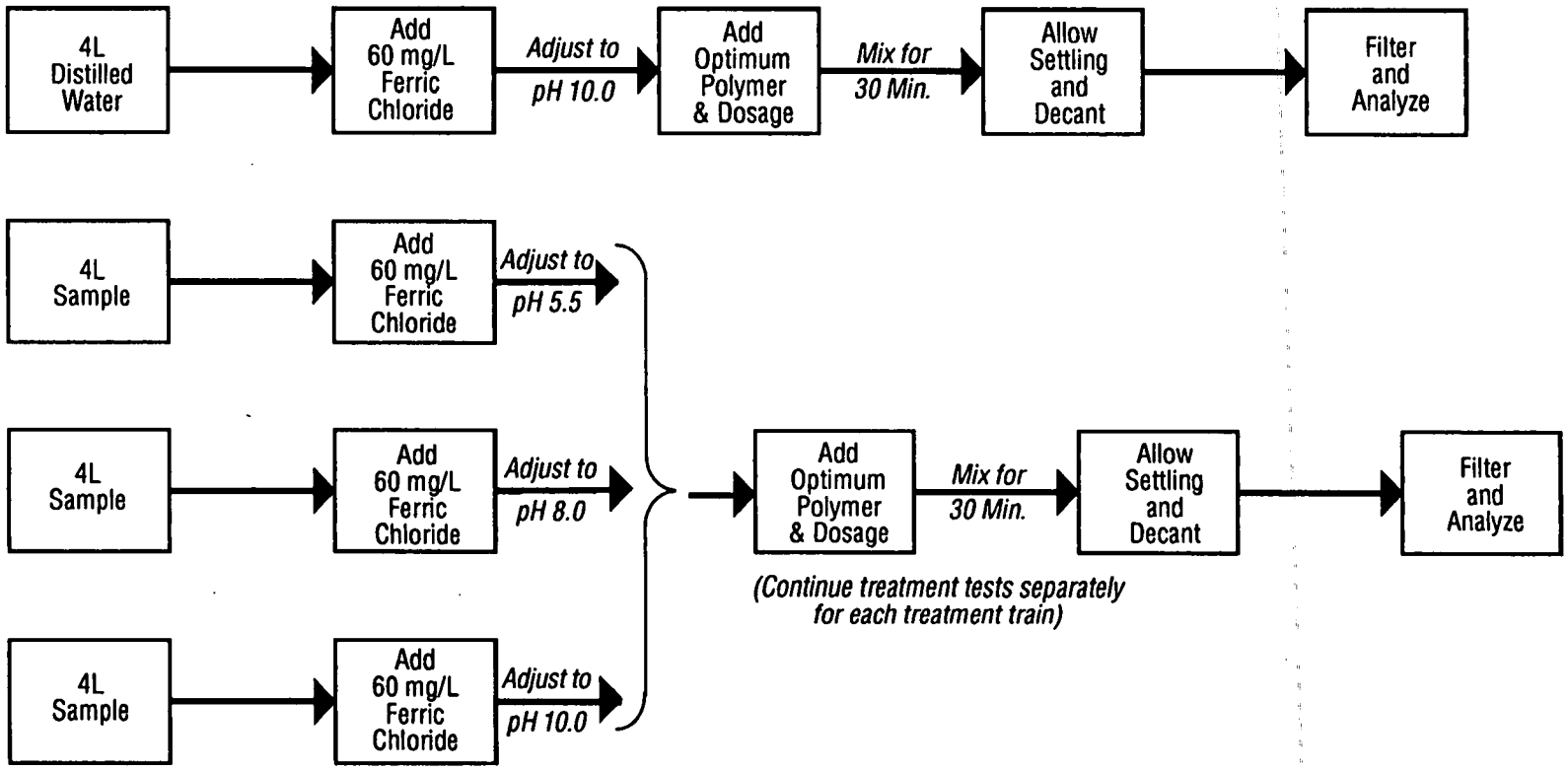

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Figure 5-9
TASK 7 - IRON COPRECIPITATION
(Concluded)

Step 3:

- Repeat Steps 1 and 2 at pH values of 8.0 and 10.0.

Step 4:

- Place 4,000 mL of distilled water into a beaker, add 60 mg/L of ferric chloride, and adjust the pH to 10.0 with calcium hydroxide.

- Place 4,000 mL of sample into each of three beakers, treat each with 60 mg/L of ferric chloride, adjust the pH to 5.5, 8.0, and 10.0, respectively, with calcium hydroxide. Add the optimum polymer type and dosage for each pH, and mix for 30 minutes.

- After mixing, settle the solids, decant, filter, and analyze for antimony, arsenic, beryllium, cadmium, chromium, iron, lead, manganese, mercury, nickel, plutonium, and uranium. (This step also applies to the blank sample.)

Step 5:

- Dispose of liquid and solid treatment wastes in accordance with Section 9.0 of this TSWP.

Task 8–Alum Coprecipitation (Figure 5-10)

Step 1:

- Place 1,000 mL of sample into each of six beakers and place them on the 6-paddle stirrer. Treat each with 60 mg/L of alum expressed as anhydrous salt in solution

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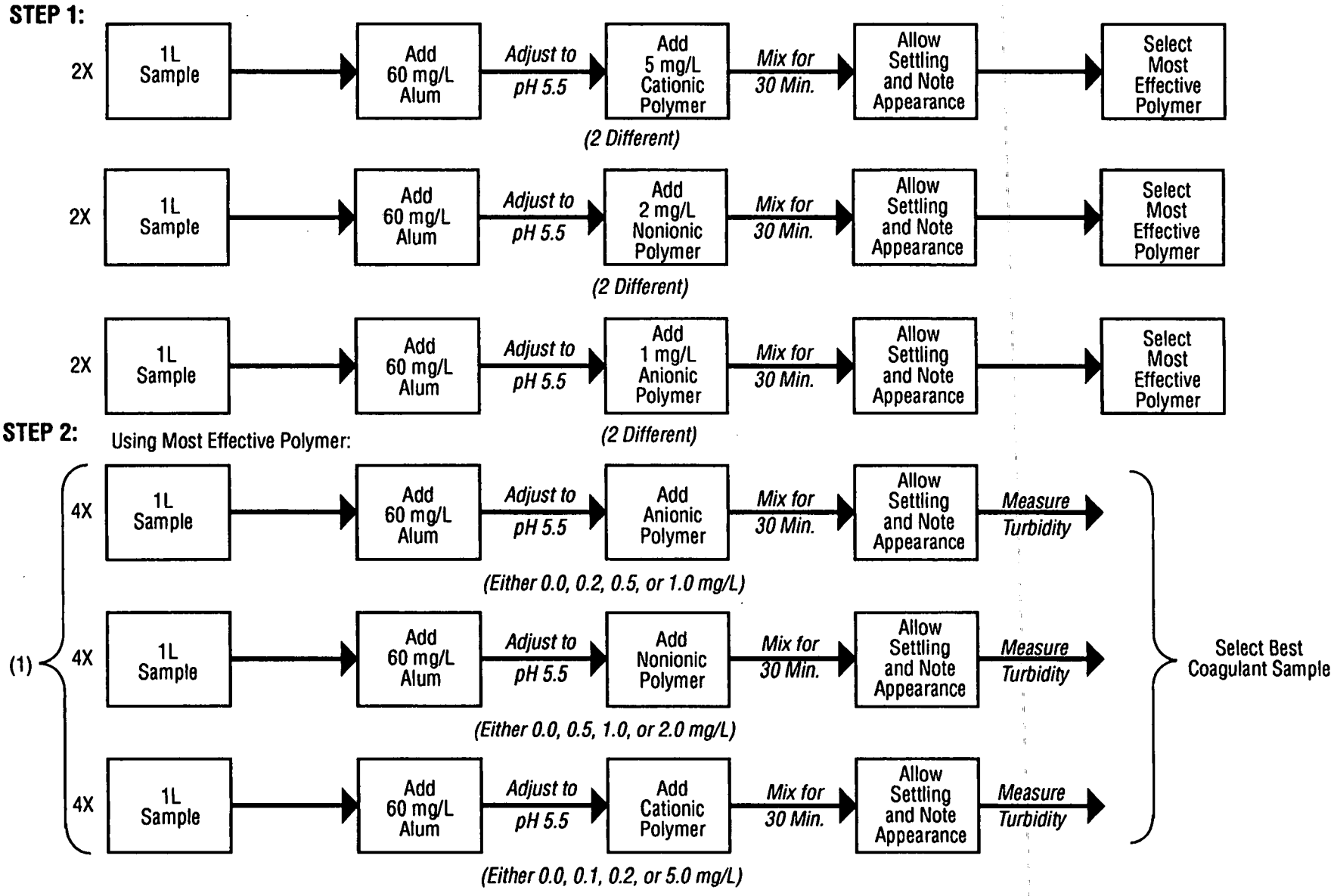
Douville	12/09/91	APPROVED BY	12/13/91	RFP TSWP 1029A



STEP 3:

(1) Repeat Above 12 Liter Samples treatment for pH 6.5 and 7.5

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Figure 5-10
TASK 8 - ALUM COPRECIPITATION

DRAWN BY	CHECKED BY	DRAWING NUMBER
Douville 12/09/91	APPROVED BY	RFP TSWP 1030A

STEP 4:

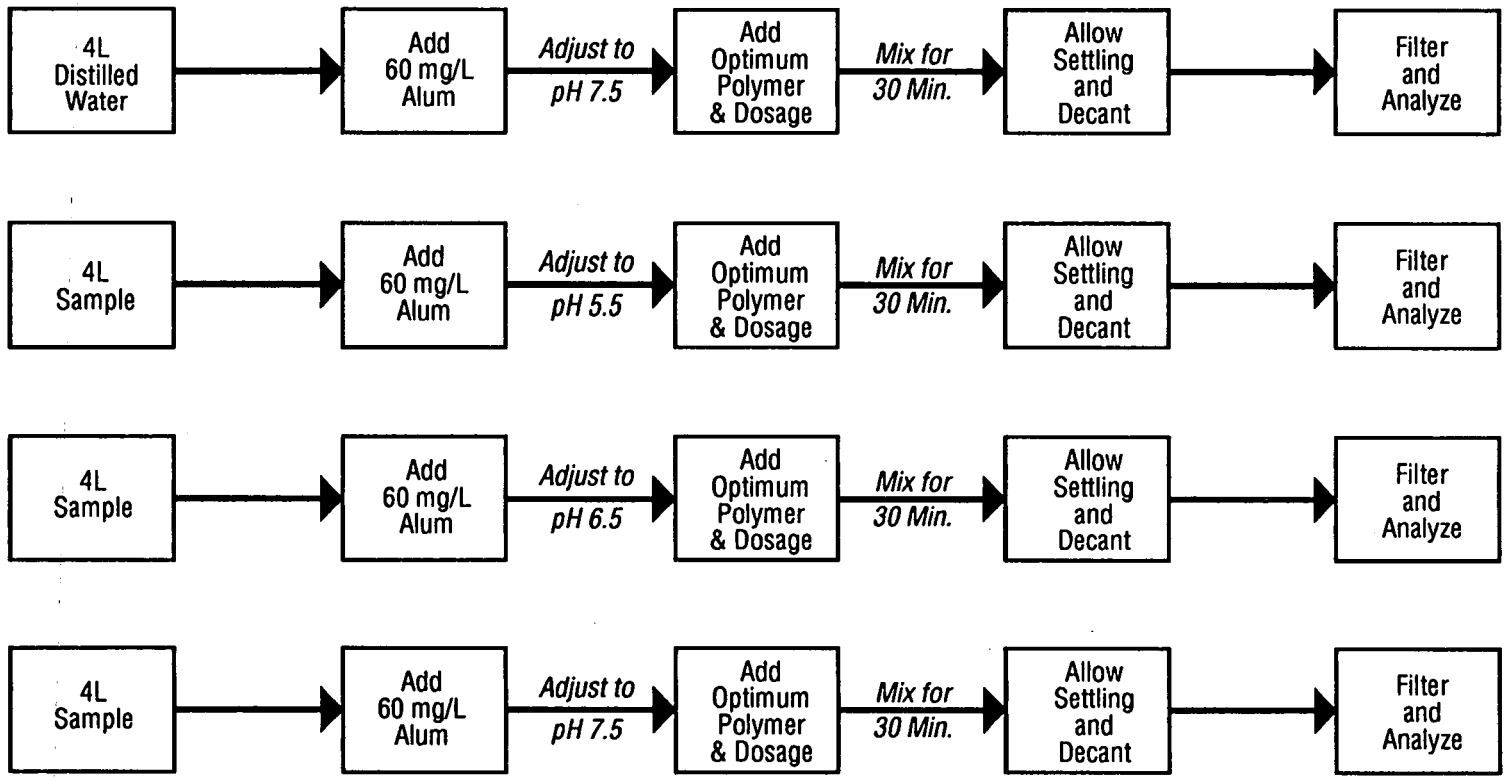

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Figure 5-10
TASK 8 - ALUM COPRECIPITATION
(Concluded)

and adjust the pH to 5.5. Add 5 mg/L of two different cationic polymers to two of the samples, 2 mg/L of two different nonionic polymers to two other samples, and 1 mg/L of two different anionic polymers to the final two samples.

- Mix for 30 minutes, remove the stirrer paddles, allow the solids to settle, and note the appearance and settling rate of the floc.

Step 2:

- Select the most effective polymer for further tests in four fresh 1,000-mL sample aliquots (three at discrete polymer doses, plus one polymer-free control). The polymer dose progression should be the same as for ferric salt testing (see Task 7). Compare the coagulant solids and note the results. Measure the turbidity.

- Transfer the best-coagulated sample to a 1-L graduated cylinder, record the settling rate and final volume of solids after 1 hour. Report the number of inches (or cm) the liquid/solid interface has advanced at 1/2 to 1-minute intervals for the first 5 to 10 minutes, and less frequently thereafter.

Step 3:

- Repeat Steps 1 and 2 at the pH values of 6.5 and 7.5.

- Place 4,000 mL of distilled water into a beaker and adjust the pH to 7.5. Add 60 mg/L of alum expressed as anhydrous salt in solution. Restore pH to 7.5.

- Place 4,000 mL of sample into each of three beakers, treat each with 60 mg/L of alum expressed as anhydrous salt in solution, adjust the pH to 5.5, 6.5, and 7.5, respectively. Add the optimum polymer type and dosage for each pH and mix for 30 minutes for the three samples and the distilled water.

- After mixing, settle the solids, decant, filter, and analyze for antimony, arsenic, aluminum, beryllium, plutonium, and uranium.

Step 5:

- Dispose of liquid and solid treatment wastes in accordance with Section 9.0 of this TSWP.

Task 9—Air Oxidation (Figure 5-11)

Step 1:

- Place 1,000 mL of sample into each of three beakers, place the beakers on magnetic stirrers, and adjust the pH to 6.5, 8.0, and 10.0, respectively. Spike with iron II and/or manganese II, if the concentration of iron and/or manganese is less than 5 mg/L. To spike, add 20 mg/L of $MnSO_4$ or $FeSO_4$.

- Bubble air through each sample with a diffusion frit for 30 minutes maintaining a flow rate sufficient for vigorous mixing without causing liquid overflow. Note any visual changes in the samples.

- Immediately upon completion of the 30-minute treatment interval, remove the air stones, allow solids to settle, filter, and analyze samples for iron and manganese.

Step 2:

- Dispose of liquid and solid treatment wastes in accordance with Section 9.0 of this TSWP.

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	Douville		12/13/91	RFP TSWP 1031A
	12/09/91	APPROVED BY	12/13/91	

STEP 1:

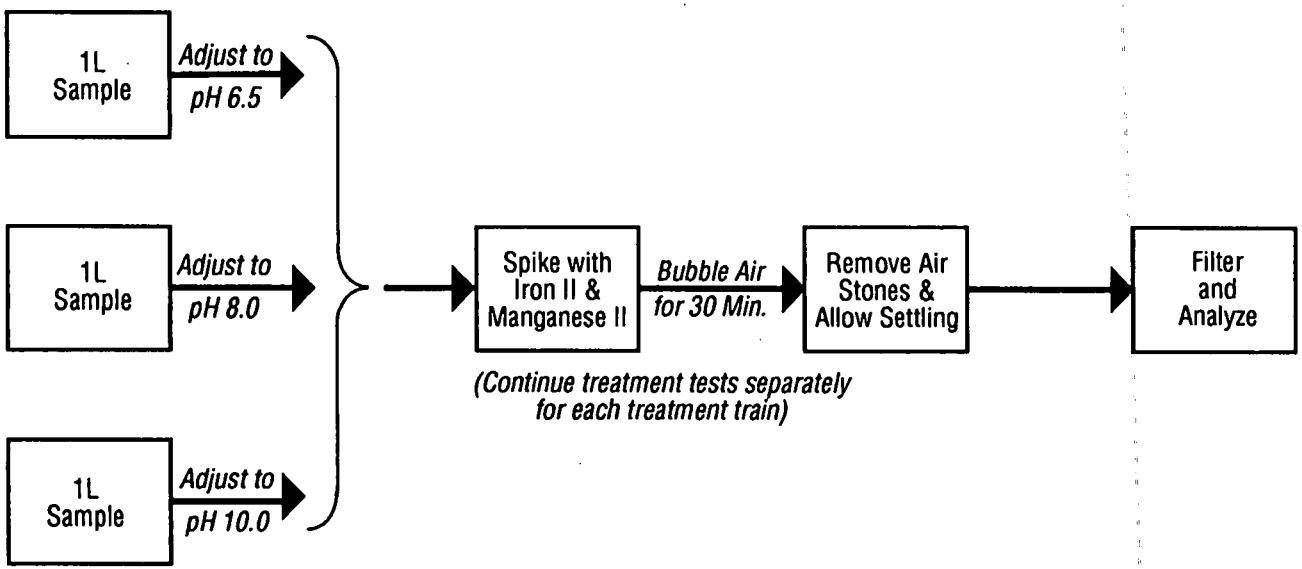

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Figure 5-11
TASK 9 - AIR OXIDATION

Task 10—Laboratory Restoration

- Suitably dispose of or store unused or unneeded reagents.
- Clean glassware and other items used during testing.
- Return leased/borrowed equipment.
- Ship samples for specialized analyses to appropriate test facilities.
- Maintain all logbooks pertaining to treatability testing for future inspection.
- Return 55-gallon drums of liquid wastes and 1 gallon containers of solid wastes to Rocky Flats for treatment/disposal/management.
- Return laboratory to pretest conditions.

5.4 SUMMARY OF SAMPLES AND ANALYSES

Table 5-1 summarizes the analyses that will be performed on the treatability influent and the effluent for all tasks, and the steps and dosages described above. All samples will be filtered prior to the analyses. The analytical and QA/QC protocols specified in the EG&G, Rocky Flats GRRASP document, Version 2.1 (DOE, 1991) will be followed for all analyses. The GRRASP methods follow EPA CLP or EPA-approved methods, and the specified QA/QC meets Level III and Level IV DQOs as described in Section 4.0 of this document.

5.5 TREATABILITY QA/QC SAMPLES

The treatability study is designed with preliminary technology screening steps, followed by a more focused data generation on technologies that appear to be promising. Because there are several

repetitive steps included for each technology, replicate experiments are deemed unnecessary. Laboratory control samples (distilled water blanks) will be carried through the treatment steps during the focused experiments. These control samples will allow for determining the contaminant introduced from the dose reagents and procedural handling steps. Table 5-1 lists the blank samples that will be processed through treatability and analyzed for the same metals as the influent samples. Additional QA/QC to determine the accuracy and precision will be in the form of laboratory QA/QC samples. These samples are described in Table 4-2.

TABLE 5-1

SUMMARY OF SAMPLES AND ANALYSES

Sample Stream		No. of Samples	Analyses[a]
Treatability Influent (composite from two groundwater and two surface water locations)		1	TAL metals, Radionuclides, Water Quality Parameters, Chromium (VI)
TASK 2–FERROUS SULFATE REDUCTION			
Step 1:	290 mg/L dose	1	Cr (total), Cr (VI), Hg, Pu239/240
	475 mg/L dose	1	Cr (total), Cr (VI), Hg, Pu239/240
	900 mg/L dose	1	Al, Fe, Se, U 233/234/235/238
Step 2:	950 mg/L dose (pH 5.0)	1	Cr (total), Cr (VI), Hg, Pu239/240
	950 mg/L dose (pH 7.5)	1	Cr (total), Cr (VI), Hg, Fe, Al, Se, Pu239/240, U 233/234/235/238
	Blank (pH 7.5)	1	Cr (total), Cr (VI), Hg, Fe, Al, Se, Pu239/240, U 233/234/235/238
TASK 3–SODIUM BISULFITE REDUCTION			
Step 1:	160 mg/L dose	1	Cr (total), Cr (VI), Hg, Pu239/240
	270 mg/L dose	1	Cr (total), Cr (VI), Hg, Pu239/240
	540 mg/L dose	1	Cr (total), Cr (VI), Hg, Al, Se, Pu239/240, U 233/234/235/238
Step 2:	540 mg/L dose (pH 2.0)	1	Cr (total), Cr (VI), Hg, Se, Pu239/240, U 233/234/235/238
	540 mg/L dose (pH 3.5)	1	Cr (total), Cr (VI), Hg, Pu239/240
	Blank (pH 2.0)	1	Cr (total), Cr (VI), Hg, Se, Pu239/240, U 233/234/235/238

[a]Although only the specific metals potentially affected by each treatment step are indicated, a CLP TAL metals analysis (23 metals) will be performed on the samples requiring metals determination.

TABLE 5-1

SUMMARY OF SAMPLES AND ANALYSES
(Continued)

Sample Stream		No. of Samples	Analyses[a]
TASK 4–STANNOUS CHLORIDE REDUCTION			
Step 1:	295 mg/L dose + alum	1	Cr (total), Cr (VI), Hg, Pu239/240
	490 mg/L dose + alum	1	Cr (total), Cr (VI), Hg, Pu239/240
	980 mg/L dose + alum	1	Cr (total), Cr (VI), Hg, Al, Se, Pu239/240, U 233/234/235/238
Step 2:	980 mg/L dose + ferric chloride	1	Cr (total), Cr (VI), Hg, Se, Pu239/240, U 233/234/235/238
	Blank + ferric chloride	1	Cr (total), Cr (VI), Hg, Se, Pu239/240, U 233/234/235/238
TASK 5–BARIUM SULFATE COPRECIPITATION			
Step 1:	25 mg/L dose	1	Ba, Ra226
	50 mg/L dose	1	Ba, Ra226
TASK 6–LIME PRECIPITATION			
Step 1 (pH 9.0):	Anionic polymer No. 1	1	Floc settling rate
	Anionic polymer No. 2	1	Floc settling rate, select the better of the two polymers
Step 2 (pH 9.0):	0.0 mg/L polymer dose	1	Floc settling rate
	0.2 mg/L polymer dose	1	Floc settling rate
	0.5 mg/L polymer dose	1	Floc settling rate
	1.0 mg/L polymer dose	1	Floc settling rate

[a]Although only the specific metals potentially affected by each treatment step are indicated, a CLP TAL metals analysis (23 metals) will be performed on the samples requiring metals determination.

TABLE 5-1

SUMMARY OF SAMPLES AND ANALYSES
(Continued)

Sample Stream		No. of Samples	Analyses[a]
Step 3.1 (pH 10.0):	Anionic polymer No. 1	1	Floc settling rate
	Anionic polymer No. 2	1	Floc settling rate, select the better of the two polymers
Step 3.2 (pH 10.0):	0.0 mg/L polymer dose	1	Floc settling rate
	0.2 mg/L polymer dose	1	Floc settling rate
	0.5 mg/L polymer dose	1	Floc settling rate
	1.0 mg/L polymer dose	1	Floc settling rate
Step 3.1 (pH 11.0):	Anionic polymer No. 1	1	Floc settling rate
	Anionic polymer No. 2	1	Floc settling rate, select the better of the two polymers
Step 3.2 (pH 11.0):	0.0 mg/L polymer dose	1	Floc settling rate
	0.2 mg/L polymer dose	1	Floc settling rate
	0.5 mg/L polymer dose	1	Floc settling rate
	1.0 mg/L polymer dose	1	Floc settling rate
Step 4 (pH 9.0):	Optimum polymer dose	1	Al, Sb, As, Be, Cd, Fe, Pb, Mn, Hg, Ni, Pu239/240, U 233/234/235/238
Step 4 (pH 10.0):	Optimum polymer dose	1	Al, Sb, As, Be, Cd, Fe, Pb, Mn, Hg, Ni, Pu239/240, U 233/234/235/238
Step 4 (pH 11.0):	Optimum polymer dose	1	Al, Sb, As, Be, Cd, Fe, Pb, Mn, Hg, Ni, Pu239/240, U 233/234/235/238

[a]Although only the specific metals potentially affected by each treatment step are indicated, a CLP TAL metals analysis (23 metals) will be performed on the samples requiring metals determination.

TABLE 5-1

SUMMARY OF SAMPLES AND ANALYSES
(Continued)

Sample Stream		No. of Samples	Analyses[a]
TASK 7–IRON COPRECIPITATION			
Step 1 (pH 5.5, 2 mg/L dose):	Cationic polymer No. 1	1	Floc settling rate
	Cationic polymer No. 2	1	Floc settling rate
	Nonionic polymer No. 1	1	Floc settling rate
	Nonionic polymer No. 2	1	Floc settling rate
	Anionic polymer No. 1	1	Floc settling rate
	Anionic polymer No. 2	1	Floc settling rate
		4	Floc settling rate
Step 2 (pH 5.5):	Optimum cationic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses		
	Optimum nonionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
	Optimum anionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
Step 3.1 (pH 8.0, 2 mg/L dose):	Cationic polymer No. 1	1	Floc settling rate
	Cationic polymer No. 2	1	Floc settling rate
	Nonionic polymer No. 1	1	Floc settling rate
	Nonionic polymer No. 2	1	Floc settling rate

[a]Although only the specific metals potentially affected by each treatment step are indicated, a CLP TAL metals analysis (23 metals) will be performed on the samples requiring metals determination.

TABLE 5-1

SUMMARY OF SAMPLES AND ANALYSES
(Continued)

Sample Stream		No. of Samples	Analyses[a]
	Anionic polymer No. 1	1	Floc settling rate
	Anionic polymer No. 2	1	Floc settling rate
		4	Floc settling rate
Step 3.2 (pH 8.0):	Optimum cationic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses		
	Optimum nonionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
	Optimum anionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
Step 3.1 (pH 10.0, 2 mg/L dose):	Cationic polymer No. 1	1	Floc settling rate
	Cationic polymer No. 2	1	Floc settling rate
	Nonionic polymer No. 1	1	Floc settling rate
	Nonionic polymer No. 2	1	Floc settling rate
	Anionic polymer No. 1	1	Floc settling rate
	Anionic polymer No. 2	1	Floc settling rate
Step 3.2 (pH 10.0):	Optimum cationic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate

[a]Although only the specific metals potentially affected by each treatment step are indicated, a CLP TAL metals analysis (23 metals) will be performed on the samples requiring metals determination.

TABLE 5-1

SUMMARY OF SAMPLES AND ANALYSES
(Continued)

	Sample Stream	No. of Samples	Analyses[a]
	Optimum nonionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
	Optimum anionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
Step 4:	Optimum polymer and dose at pH 5.5	1	As, Sb, Be, Cd, Cr (total), Cr (VI), Fe, Pb, Mn, Hg, Ni, Pu239/240, U 233/234/235/238
	Optimum polymer and dose at pH 8.0	1	As, Sb, Be, Cd, Cr (total), Cr (VI), Fe, Pb, Mn, Hg, Ni, Pu239/240, U 233/234/235/238
	Optimum polymer and dose at pH 10.0	1	As, Sb, Be, Cd, Cr (total), Cr (VI), Fe, Pb, Mn, Hg, Ni, Pu239/240, U 233/234/235/238
	Blank at pH 10.0	1	As, Sb, Be, Cd, Cr (total), Cr (VI), Fe, Pb, Mn, Hg, Ni, Pu239/240, U 233/234/235/238
TASK 8–ALUM COPRECIPITATION			
Step 1 (pH 5.5):	Cationic polymer No. 1 at 5 mg/L dose	1	Floc settling rate
	Cationic polymer No. 2 at 5 mg/L dose	1	Floc settling rate
	Nonionic polymer No. 1 at 2 mg/L dose	1	Floc settling rate

[a]Although only the specific metals potentially affected by each treatment step are indicated, a CLP TAL metals analysis (23 metals) will be performed on the samples requiring metals determination.

TABLE 5-1

SUMMARY OF SAMPLES AND ANALYSES
(Continued)

Sample Stream		No. of Samples	Analyses[a]
	Nonionic polymer No. 2 at 2 mg/L dose	1	Floc settling rate
	Anionic polymer No. 1 at 1 mg/L dose	1	Floc settling rate
	Anionic polymer No. 2 at 1 mg/L dose	1	Floc settling rate
Step 2 (pH 5.5):	Optimum cationic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
	Optimum nonionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
	Optimum anionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
Step 3.1 (pH 6.5):	Cationic polymer No. 1	1	Floc settling rate
	Cationic polymer No. 2	1	Floc settling rate
	Nonionic polymer No. 1	1	Floc settling rate
	Nonionic polymer No. 2	1	Floc settling rate
	Anionic polymer No. 1	1	Floc settling rate
	Anionic polymer No. 2	1	Floc settling rate
Step 3.2 (pH 6.5):	Optimum cationic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate

[a]Although only the specific metals potentially affected by each treatment step are indicated, a CLP TAL metals analysis (23 metals) will be performed on the samples requiring metals determination.

TABLE 5-1

SUMMARY OF SAMPLES AND ANALYSES
(Continued)

Sample Stream		No. of Samples	Analyses[a]
	Optimum nonionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
	Optimum anionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
Step 3.1 (pH 7.5):	Cationic polymer No. 1	1	Floc settling rate
	Cationic polymer No. 2	1	Floc settling rate
	Nonionic polymer No. 1	1	Floc settling rate
	Nonionic polymer No. 2	1	Floc settling rate
	Anionic polymer No. 1	1	Floc settling rate
	Anionic polymer No. 2	1	Floc settling rate
Step 3.2 (pH 7.5):	Optimum cationic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
	Optimum nonionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
	Optimum anionic polymer at 0.0, 0.2, 0.5 and 1.0 mg/L doses	4	Floc settling rate
Step 4:	Optimum polymer at pH 5.5	1	As, Sb, Be, Cd, Cr (total), Cr (VI), Fe, Pb, Mn, Hg, Ni, Pu239/240, U 233/234/235/238

[a]Although only the specific metals potentially affected by each treatment step are indicated, a CLP TAL metals analysis (23 metals) will be performed on the samples requiring metals determination.

TABLE 5-1

SUMMARY OF SAMPLES AND ANALYSES
(Concluded)

	Sample Stream	No. of Samples	Analyses[a]
	Optimum polymer at pH 6.5	1	As, Sb, Be, Cd, Cr (total), Cr (VI), Fe, Pb, Mn, Hg, Ni, Pu239/240, U 233/234/235/238
	Optimum polymer at pH 7.5	1	As, Sb, Be, Cd, Cr (total), Cr (VI), Fe, Pb, Mn, Hg, Ni, Pu239/240, U 233/234/235/238
	Blank at pH 7.5	1	As, Sb, Be, Cd, Cr (total), Cr (VI), Fe, Pb, Mn, Hg, Ni, Pu239/240, U 233/234/235/238
TASK 9–AIR OXIDATION			
Step 1:	Fe (II) and/or Mn (II) spike at pH 6.5	1	Fe, Mn
	Fe (II) and/or Mn (II) spike at pH 8.0	1	Fe, Mn
	Fe (II) and/or Mn (II) spike at pH 10.0	1	Fe, Mn

[a]Although only the specific metals potentially affected by each treatment step are indicated, a CLP TAL metals analysis (23 metals) will be performed on the samples requiring metals determination.

6.0 EQUIPMENT AND MATERIALS

The equipment and materials necessary for performing the treatability tests are listed in Tables 6-1 and 6-2.

6.1 EQUIPMENT CALIBRATION, CALIBRATION RECORDS, AND CONTROL

Laboratory equipment used in the treatability study (such as a pH meter and an oxidation/reduction potential meter) will be identified in the log book(s) by manufacturer's serial number or another suitable unique number. This equipment will be used and calibrated in strict accordance with the manufacturer's instructions. Records of calibration techniques/procedures, source of calibration standard solutions, and date/time of calibration will be maintained in the laboratory log books. The date/time of the last calibration of each instrument will be entered on a label which is attached to the instrument.

Manufacturer's operation, calibration, and maintenance instructions will be kept in close proximity to the equipment during the entire duration of the treatability study. Equipment/instruments will be maintained in accordance with the manufacturer's instructions.

TABLE 6-1

EQUIPMENT AND MATERIALS

Item	Quantity
6-liter clear containers (glass or plastic)	6
6-liter filter flasks (or largest available)	6
4-liter glass beakers	8
2-liter glass beakers	8
Graduated cylinder (1,000 mL)	2
6-paddle stirrer	1
Magnetic mixers	6
pH meter(s) with probes[1]	3
Oxidation reduction potential meter with probes	1
Assorted laboratory glassware, equipment, accessories, and supplies	

[1]Special probe required for measuring over 1,000 mv. This is a long delivery item.

TABLE 6-2

CHEMICAL SUPPLIES

Compound	Quantity
Stannous chloride dihydrate (technical or reagent grade)	1 lb
Ferrous sulfate hepta-hydrate (technical or reagent grade)	1 lb
Sodium bisulfite, (technical or reagent grade)	1 lb
Barium chloride (anhydrous or hydrated) (technical or reagent grade)	1/2 lb
Sodium sulfate (anhydrous or hydrated) (technical or reagent grade)	1/2 lb
Ferric chloride hexahydrate (technical or reagent grade)	1 lb
Aluminum sulfate, hydrated (Alum) (technical grade)	1 lb
Calcium hydroxide (technical or reagent grade)	1 lbs
Hydrochloric acid, concentrated (35% solution) (technical or reagent grade)	2 gallon
Assorted anionic, cationic, and nonionic water treatment polymers (contact water treatment suppliers for appropriate polymers)	1/2 oz., ea.

7.0 DATA MANAGEMENT

The treatability study will generate observational data from the screening tests as well as analytical data for the treatability effluents. The study will also generate pretreatment analytical data developed to characterize pretreatment surface water and groundwater. Observations of the tests will be documented in logbooks assigned to the laboratory personnel. The effluents likely will be analyzed by a non-Rocky Flats Plant laboratory. The laboratory shall have satisfactory QA/QC procedures to track and maintain custody of samples and data.

Procedures for logging of field sample collection activities are documented in the Sampling Plan, Appendix A.

At a minimum, the treatability testing logbooks will document the following:

- Testing procedures
- Departures from protocols and reasons for departures
- Instrument calibration
- Sampling methods
- Chemical additions
- Test observations

Standard bench sheets will be designed to allow uniform recording of the test conditions and observations.

Many of the observations of experimental results are qualitative, and laboratory personnel will need to describe results such as settling rate and floc size in qualitative terms to indicate relative

differences between processes. Experimental results which are quantitative (such as pH) will be reported to the accuracy level of the measurement device.

Comprehensive data packages will be generated by the outside analytical laboratory for the metals analyses of the treatability effluents in accordance with the Level III or IV analytical QA/QC requirements. Similar data packages will be generated for radionuclide and water quality parameters, so that the accuracy and the precision of the results can be independently verified. The analytical data packages will be tracked and managed according to the tests performed and laboratory QC group numbers assigned by the laboratory. Where applicable, QC data will also be obtained in an electronic format to facilitate data uploading into the project data base.

Monthly progress reports will also be prepared during the feasibility study testing. These reports will include the following:

- Waste stream studied
- Treatability test number
- Date sample collected
- Where sample stored prior to treatment
- Date treatment initiated
- Initial sample weight
- Date treatment concluded
- Final residue and unused sample weight
- Where residue stored prior to return to permitted storage area
- Date residue returned to permitted storage area

This information will be presented in a table format with one table per waste stream/process. This information will be provided to EG&G RCRA Permitting Division on a monthly basis.

8.0 DATA ANALYSIS AND INTERPRETATION

Upon completion of treatability testing, data will be presented and interpreted in accordance with Section 6.7 of the Treatability Study Plan and Guidance for Conducting Treatability Studies Under CERCLA (EPA, 1989). Data will be summarized and evaluated to determine the validity of measurements and performance of the treatment processes. Section 3.0 of the RFP Quality Assurance Project Plan (QAPjP) describes the requirements for data reduction, validation, useability criteria, and reporting of data. Appendix C, an addendum of the QAPjP, addresses the specific QA requirements for performing treatability studies of redox processes. Appendix C of the draft QAPjP is included as Appendix D of this document.

8.1 MEASUREMENTS OF PERFORMANCE

Data checking to assess data for precision (for example, the relative percent difference for duplicate matrix spikes), accuracy (for example, the percent recovery of matrix spikes), and completeness (for example, the percentage of data that are valid) will be conducted in accordance with Functional Guidelines for Laboratory Data Validation (EPA, 1988). Where guidelines for data validation are not available, such as for water quality parameters and radionuclides, standard operating procedures will be prepared based on the analytical methods utilized and the QA/QC measures included in the analyses. The EMD OPS will allow uniform validation of the water quality parameter and radionuclide data. Qualified personnel not directly associated with the laboratory experiments or laboratory analyses will perform the data validation function at the direction of the treatability study contractor. The verified/validated data will be reduced to graphical or tabular form for interpretation. Conclusions concerning the effectiveness of processes will be deduced directly from the treatability data and comparison with ARARs/TBCs. The implementation and cost of the processes will be indirectly deduced by calculations based on the treatability data.

Engineering judgements are required in several of the experimental tasks. These judgements include such observations as sludge appearance, floc size, and similar items. Data consistency will be maintained by having the same laboratory technician make and record all similar observations. Engineering judgements will be observed by an experienced process engineer.

9.0 RESIDUAL MANAGEMENT

All liquid wastes generated during treatability testing will be stored in properly labeled 55-gallon U.S. Department of Transportation-approved (DOT) containers. Solid residues will be stored in 1-gallon resealable DOT metal containers. It is estimated that the amount of liquid waste, including used samples, will be 550 gallons (ten 55-gallon drums) and the amount of solid waste will be approximately 150 gallons by volume.

All unused treatability samples and residues will be returned to the Rocky Flats Plant under the Treatability Study Exemption Rule. In accordance with 40 CFR 261.4(f), samples and residues will be returned within 90 days from the completion of treatability testing, or within 1 year from the sample shipment date from RFP to the facility. All unused samples will be contained separately from sample residues.

The outside contractor laboratory will be responsible for properly disposing of any unused portions of the effluent samples submitted for analyses, and incidental wastes generated during sample preparation and analysis.

10.0 REPORTS

The oxidation/reduction treatability study results will be summarized in a Treatability Study Report. The report will be prepared upon completion of treatability study testing and will summarize the test results and discuss any improvements or additional testing that may need to be conducted. The report will also describe the technology's effectiveness in removing metals and radionuclides from contaminated water and will identify any additional data needs. The format of the report will follow the format presented in the Guidance for Conducting Treatability Studies Under CERCLA (EPA, 1989). The format is presented in Table 10-1.

TABLE 10-1

ORGANIZATION OF THE TREATABILITY STUDY REPORT

1. Introduction
   - 1.1 Site description
     - 1.1.1 Site name and location
     - 1.1.2 History of operations
     - 1.1.3 Prior removal and remediation activities
   - 1.2 Waste stream description
     - 1.2.1 Waste matrices
     - 1.2.2 Pollutants/chemical
   - 1.3 Remedial technology description
     - 1.3.1 Treatment process and scale
     - 1.3.2 Operating features
   - 1.4 Previous treatability studies at the site

2. Conclusions and Recommendations
   - 2.1 Conclusions
   - 2.2 Recommendations

3. Treatability Study Approach
   - 3.1 Test objectives and rationale
   - 3.2 Experimental design and procedures
   - 3.3 Equipment and material
   - 3.4 Sampling and Analysis
     - 3.4.1 Waste stream
     - 3.4.2 Treatment process
   - 3.5 Data management
   - 3.6 Deviations from the work plan

4. Results and Discussion
   - 4.1 Data analysis and interpretation
     - 4.1.1 Analysis of waste stream characteristics
     - 4.1.2 Analysis of treatability study data
     - 4.1.3 Comparison to test objectives
   - 4.2 Quality assurance/quality control
   - 4.3 Costs/schedule for performing the treatability study
   - 4.4 Key contacts

References

Appendices
- A. Data summaries
- B. Standard operating procedures

Source: EPA, 1989.

11.0 SCHEDULE

The Oxidation/Reduction Treatability Study shall consist of three phases during a 29-week period. Phase I shall consist of 3 weeks to finalize sampling logistics, and 2 weeks to perform field sampling. Phase II shall consist of 4 weeks to perform the treatability study followed by 10 weeks to receive and analyze the treatability study data. Phase III shall consist of 10 weeks to develop, review and finalize the Treatability Study Report (TSR). An approximate project schedule to illustrate the timing, duration, and interrelationship between phases for the Oxidation/Reduction Treatability Study is shown in Figure 11-1.

DRAWN BY	Douville	CHECKED BY	YBS	12/11/91	DRAWING NUMBER	RFP TSWP 1032A
	12/09/91	APPROVED BY	JAS	12/13/91		

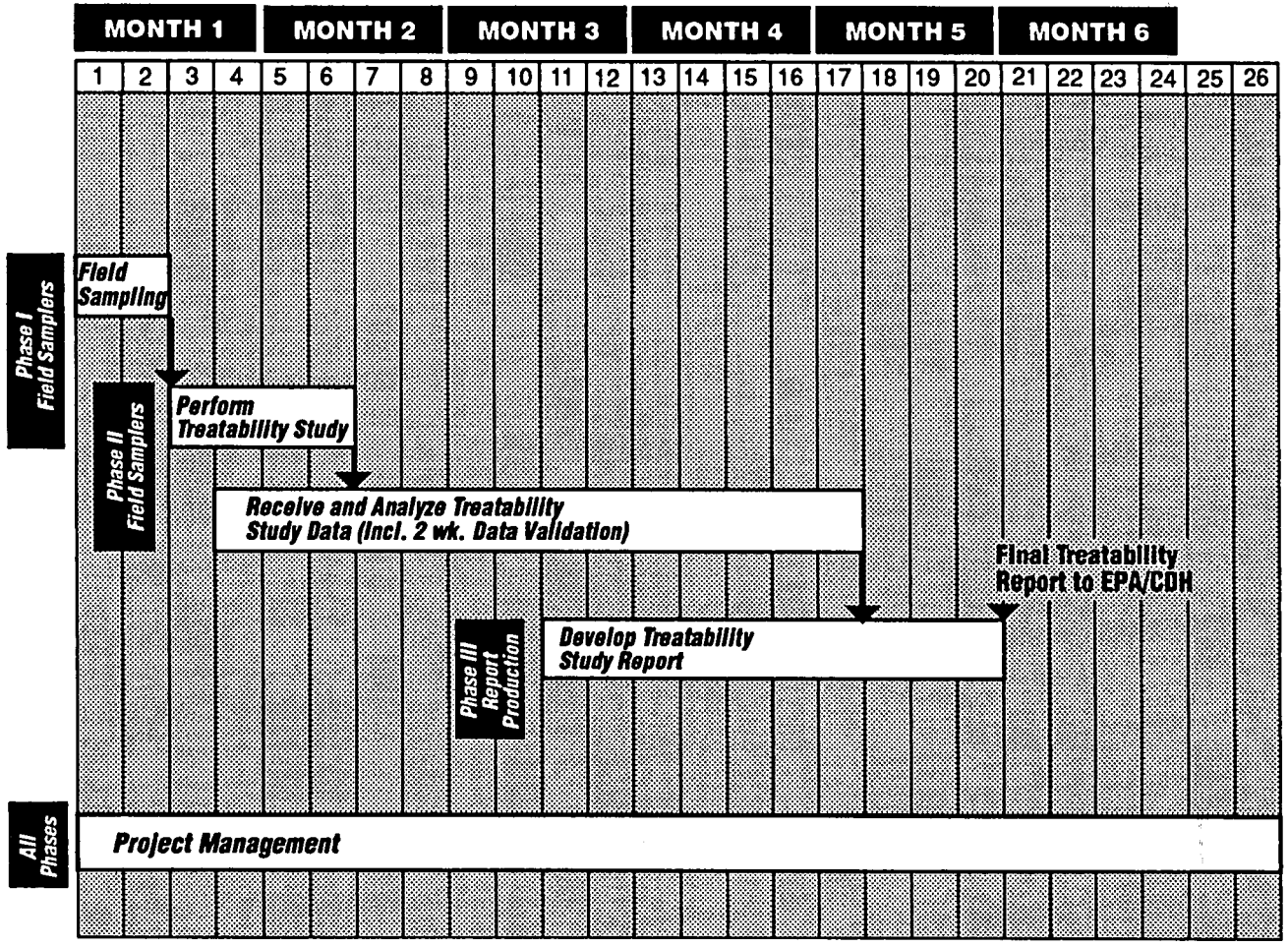


Figure 11-1
PROGRAM SCHEDULE

12.0 MANAGEMENT AND STAFFING

This section describes the management approach and staffing for the treatability study. The lines of authority and responsibilities of each treatability study team member are described.

12.1 INTRODUCTION

The objective of project management during the treatability studies is to direct and document project activities so that data and evaluations generated meet the goals and objectives of the TSWP.

Specific project management activities that shall occur throughout the treatability studies include the following:

- Meetings
- Cost and schedule control
- Data management
- Quality control
- Health and safety

These activities shall be conducted to identify potential problems quickly enough to make necessary corrections and keep the project focused on its objectives, on schedule, and within budget.

12.2 PROJECT TEAM

The project team for the treatability study at the Rocky Flats Plant is comprised of individuals from various technical disciplines. This section discusses the responsibilities of the respective key management and personnel. Each project team member should review this section with particular

interest as to each other's responsibilities. This understanding will help in overall project coordination and ensure understanding of the respective jobs to be done. Figure 12-1 depicts the treatability study project organization. The specific responsibilities of key management and personnel are described in the following subsection.

12.2.1 EG&G Program Manager

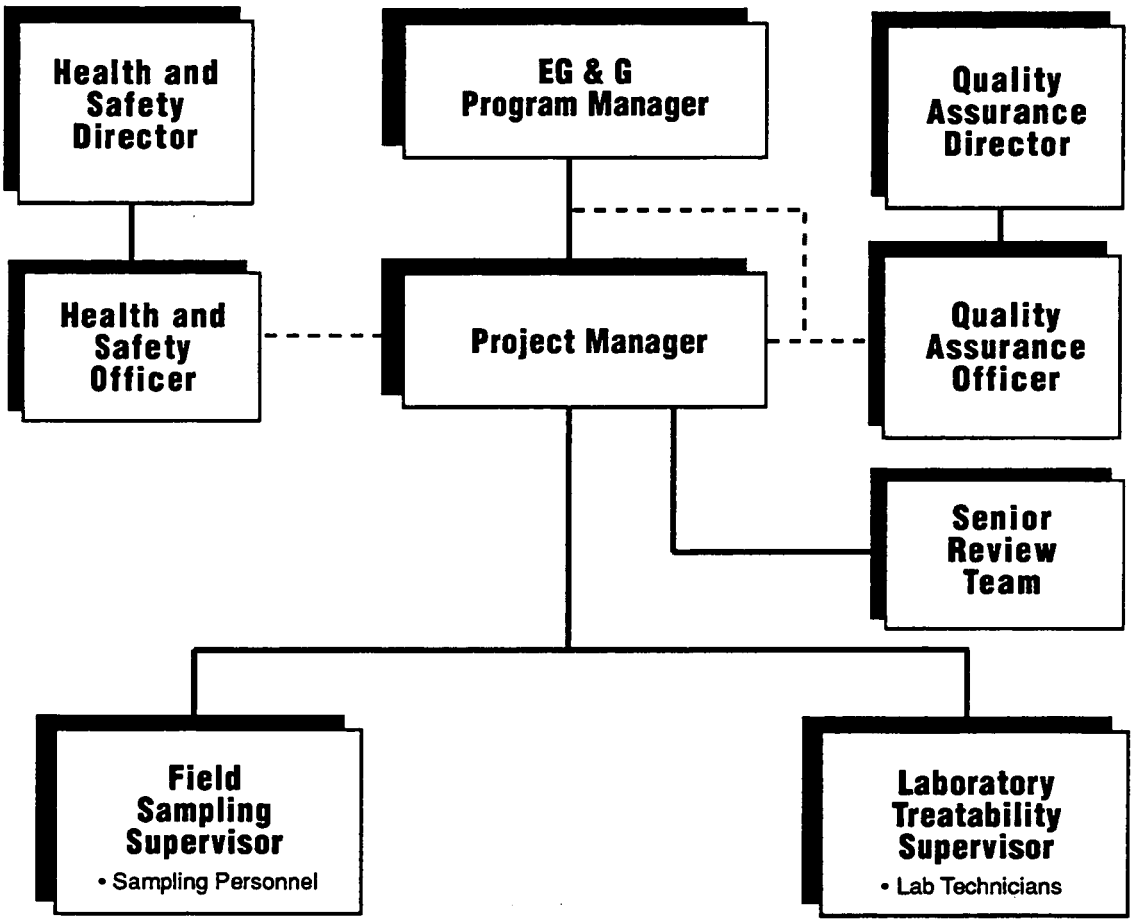
The EG&G program manager's role is to oversee and ensure the work progresses according to the priorities and objectives established during treatability study project planning. This role requires planning project scopes and deriving cost estimates for the specific tasks and activities described in the work plan. The EG&G program manager shall also facilitate the interaction among EG&G staff and contractor personnel.

12.2.2 Senior Review Team

The senior review team's responsibilities include continued quality control (QC) review of project deliverables. In general, these include the Treatability Study Sampling Plan (TSSP) and the Treatability Study Report (TSR).

12.2.3 Project Manager

The project manager (PM) is responsible for the coordination of all activities and tasks and project administration. The PM's responsibility includes quality control and technical excellence of all project aspects, and also extends to meeting assigned project budgets and schedules. The project manager shall be kept aware of major deviations from the scope and procedures established in the project documents (such as the Treatability Study Work Plan or the Sampling Analysis Plan) prior to their implementation. The PM will ensure that deliverables clearly present the results of the treatability study.



12. 2. 4 Health and Safety Officer (HSO)

The HSO is responsible for the establishment and implementation of health and safety requirements, and any monitoring programs. The maintenance of Health and Safety Records and monitoring equipment is also the responsibility of this person. The HSO will monitor compliance with health and safety requirements through audits.

12. 2. 5 Quality Assurance Officer (QAO)

The QAO is responsible for development and implementation of quality requirements, and monitors compliance through field and records audits. The QAO provides general oversight and guidance on quality issues, and sets procedures for equipment calibration and maintenance.

Figure 12-1
MANAGEMENT ORGANIZATION
ROCKY FLATS TSWP

12.2.4 Health and Safety Officer (HSO)

The HSO is responsible for the establishment and implementation of health and safety requirements, and any monitoring programs. The maintenance of Health and Safety Records and monitoring equipment is also the responsibility of this person. The HSO will monitor compliance with health and safety requirements through audits.

12.2.5 Quality Assurance Officer (QAO)

The QAO is responsible for development and implementation of quality requirements, and monitors compliance through field and records audits. The QAO provides general oversight and guidance on quality issues, and sets procedures for equipment calibration and maintenance.

12.2.6 Sampling Field Supervisor

The sampling field supervisor shall be responsible for ensuring that the Sampling Plan (Appendix A of this document) is adhered to by sampling personnel, including proper identification of sampling locations, implementation of sample designation and sample handling procedures, use of proper sampling equipment, calibration and maintenance of equipment, and completion of required paperwork.

12.2.7 Laboratory Treatability Supervisor

The laboratory treatability supervisor's responsibilities include ensuring that treatability testing procedures are followed and documented, including proper sample designation and handling procedures, use of proper test equipment, and calibration and maintenance of test equipment.

12.2.8 Sampling Personnel

Sampling personnel responsibilities relate to both groundwater and surface water sampling. Their responsibilities include sample collection, sample documentation and chain of custody, initial packing of samples, shipment of samples, and decontamination of sampling equipment and vehicles.

12.2.9 Laboratory Technicians

The laboratory technicians shall be responsible for performing the treatability tests, maintaining equipment and materials, and following experimental procedures and analytical methods. Their responsibilities include the following:

- Daily documentation of treatability testing results and other pertinent information in log books.

- Proper sample collection, designation, documentation, and chain of custody of treatability samples for outside laboratory analysis.

TITLE: Regulatory Requirements for Onsite and Offsite Testing

Approved By:

Name (Date)

13.0 REGULATORY REQUIREMENTS FOR ONSITE AND OFFSITE TESTING

If the treatability study is conducted offsite, sample collection and shipping restrictions will be followed to comply with the Sample Exclusion Provision (40 CFR 261.4(d)) of RCRA. This provision includes environmental samples used in small-scale treatability studies and is referred to as the Federal Treatability Study Exemption Rule. In accordance with this rule, samples that are collected, stored, or transported to an offsite laboratory or testing facility will be exempt from the RCRA generator and transporter requirements (40 CFR Parts 262 and 263) by following these guidelines:

- No more than 1,000 kilograms (kg) of the water to be used in the TS may be shipped to the offsite laboratory.

- Check the sample package—*before shipment*. It must not leak, spill, or vaporize from its packaging during shipment, and the transportation of each sample shipment must comply with U.S. Department of Transportation (DOT), U.S. Postal Service (USPS), or any other applicable regulations for shipping hazardous materials. All sample packages must surveyed for radioactivity following Rocky Flats Plant and DOT requirements. Packages must be appropriately labelled after surveys, according to DOT regulations (49 CFR 173).

- Check the permit status of the laboratory or testing facility. The water samples can only be shipped to a laboratory or testing facility that is exempt under 40 CFR 261.4(f) or that has an appropriate RCRA permit or interim status. Since the samples are anticipated to contain radionuclides, all laboratories (including analytical laboratories) handling the samples must be licensed by the Nuclear Regulatory Commission (NRC) or the applicable state agency if they have NRC

licensing authority for handling, analyzing, treating, or storing radioactive material. The license must be inclusive of the radionuclides expected and allow amounts of those radionuclides in excess of the quantities anticipated.

If the treatability study is conducted onsite, substantive compliance with federal, state, or local requirements will be demonstrated.

The following information must be maintained for each individual waste stream:

- The date the sample was collected.
- The date the sample was received at the treatability study unit.
- The total quantity in kg of "as received" waste in storage per day at the treatability study facility.
- If the "as received" waste sample was stored prior to initiating the treatability test, state where it was stored.
- The quantities and types of waste subjected to the treatability study.
- The date treatment was initiated, and the amount of "as received" waste introduced to treatment each day. (For example, if the treatment process is conducted in a glovebox, *and* an individual sample is treated in multiple runs, *then* the day the entire sample enters the glovebox is the date initiation of treatment for the sample.)
- The dates of initiation and conclusion of each treatability test.

- The final disposition of residues and unused samples from each treatability study (such as which RCRA-permitted hazardous waste storage area the residues and unused samples wered stored in).

- Records of any spills or releases.

- Records that show compliance with the treatment rate limits, and the storage time and quantity limits, must be kept for a minimum of 3 years after completion of the treatability study.

Monthly reporting will be required for the treatability study. These reports will include the following:

- The waste stream studied
- The treatability test number
- The date the sample was collected
- Where sample was stored prior to treatment
- The date treatment was initiated
- The initial sample weight
- The date treatment concluded
- The final residue and unused sample weight
- Where the residue was stored prior to its return to the permitted storage area
- The date the residue was returned to permitted storage area

14.0 REFERENCES

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Patterson, 1985. (Editors Note: Under search; will be included in next draft.)

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APPENDIX A. SAMPLING PLAN

This Sampling Plan presents information concerning sample location; sampling equipment and procedures; sample designation; and handling, shipping, and documentation procedures for the field sampling effort associated with the Oxidation/Reduction Treatability Study.

This Sampling Plan is divided into the following sections:

- Sampling Locations and Procedures
- Field Measurements
- Field Data Documentation and Procedures
- Sample Containers, Volumes, Preservatives, and Holding Times
- Sample Designation System
- Sample Custody
- Sample Packaging and Shipping

A.1 SAMPLING LOCATIONS AND PROCEDURES

The sampling locations and procedures are described in this section. This discussions includes the rationale for why each sampling point was chosen or rejected for inclusion in this Treatability Study. Primary and alternate (when available or appropriate) sampling locations are given for groundwater and surface water.

A.1.1 Sampling Locations

Groundwater and surface water sampling locations were determined by reviewing data made available through the following reports:

- DOE-496, Final Surface Water Interim Measure/Interim Remedial Action Plan/ Environmental Assessment and Decision Document, March 8, 1991 (DOE, 1991b).

- Solar Ponds Interceptor Trench System Groundwater Management Study, Rocky Flats Plant Site, Task 7 of the Zero Offsite Water Discharge Study, January 15, 1991 (DOE, 1991c).

- 1990 Groundwater Monitoring Report for Regulated Units at the Rocky Flats Plant, Volume I, March 1, 1991 (DOE, 1990a).

The intent, when selecting appropriate sampling locations, was to identify groundwater and surface water sampling locations that would provide *representative* (concentrations for selected constituents are within one standard deviation of the mean concentrations) and *above-average* (concentrations for selected constituents are greater than one standard deviation from the mean concentrations) concentrations for sitewide chemicals of concern shown here in Table A-1 and originally identified in Table 5-2 (Page T-13) of the Final Treatability Studies Plan, Rocky Flats Plant Report dated May 30, 1991 (DOE, 1991a).

One difficulty when selecting sampling location for subsequent treatability tests is the variable distribution of chemicals between sampling locations. For example, an above-average concentration of cadmium is not necessarily found in the same groundwater well containing an above-average concentration of arsenic (for instance, above-average concentrations of each chemical of concern

Table A-1

SITEWIDE CHEMICALS OF CONCERN

Groundwater	Surface Water
METALS	
	Aluminum
	Antimony
Arsenic	Arsenic
	Barium
	Beryllium
Cadmium	Cadmium
Chromium	Chromium
Iron	Iron
Lead	Lead
Manganese	Manganese
	Mercury
	Nickel
Selenium	Selenium
RADIONUCLIDES	
Gross Alpha	Gross Alpha
	Gross Beta
	Plutonium 239 and 240
	Radium 226
	Tritium
	Uranium (Total)

Note: Concentrations of these constituents exceed potential ARARs/TBCs in two or more Operational Units (OUs).

may be found in different sampling locations). In general, inherent obstacles in selecting representative sampling locations included:

- Spacial variability of chemicals of concern
- Limited availability of sitewide data
- Lack of an established methodology for selecting sampling locations

An attempt was made, however, to limit the number of locations sampled and to select locations that contained both metals and radionuclides of concern.

If sufficient sample volume is not available from a specified sampling location, then the additional sample volume required will be taken from the alternate sampling location. The two volumes will be combined into one composite sample for use in the treatability study.

A.1.1.1 Surface Water Sampling Locations

Surface water data made available for the selection of surface water sampling locations was contained in the following two documents:

- DOE-496, Final, Surface Water Interim Measure/Interim Remedial Action Plan/ Environmental Assessment and Decision Document, March 8, 1991 (DOE, 1991b).

- Solar Ponds Interceptor Trench System Groundwater Management Study, Rocky Flats Plant Site, Task 7 of the Zero Offsite Water Discharge Study, January 15, 1991 (DOE, 1991c).

These reports present (or allow the calculation of) average temporal concentrations/activities at surface water sampling locations for the identified chemicals of concern. Average concentrations for metals of concern in OU 2 are shown in Table A-2, while average activities for radionuclides of concern are shown in Table A-3.

Table A-2

**SURFACE WATER
METALS (TOTAL) OF CONCERN
OU 2 AVERAGES**

Location	Potential ARAR	Al (mg/l) 0.200	Sb (mg/l) 0.146	As (mg/l) 0.05	Ba (mg/l) 1.0	Be (mg/l) 0.005	Cd (mg/l) 0.01	Cr (mg/l) 0.05	Fe (mg/l) 0.30	Pb (mg/l) 0.05	Mn (mg/l) 0.050	Hg (mg/l) 0.002	Ni (mg/l) 0.2	Se (mg/l) 0.01
Station 63		0.75	0.030	0.0030	0.107	0.0025	0.0025	0.0050	1.320	0.0660	0.4650	0.0001	0.0200	0.0110
Station 64		5.6	0.030	0.0053	0.156	0.0025	0.0040	0.0170	6.363	0.0025	0.1579	0.0001	0.0210	0.0055
Station 103		36	0.030	0.0185	1.102	0.0056	0.0061	0.0410	40	0.1528	2.7192	0.0003	0.0622	0.0025
903 PAD		4.4	0.030	0.0049	0.227	0.0026	0.0025	0.0083	5.16	0.0147	0.2222	0.0001	0.0225	0.0032
Station 53		1.7	0.030	0.0050	0.273	0.0030	0.0025	0.0050	8.840	0.0110	0.5873	0.0002	0.0200	0.0025
South Walnut Creek		4.0	0.031	0.0050	0.233	0.0051	0.0030	0.0151	12.000	0.0140	0.3603	0.0002	0.294	0.0026
Station 59		6.7	0.040	0.0050	0.209	0.0037	0.0025	0.0090	5.786	0.0124	0.0723	0.0002	0.0200	0.0044
Geometric Mean (x)		4.4	0.031	0.0056	0.247	0.0034	0.0031	0.0079	7.259	0.0184	0.353	0.00016	0.0254	0.0039
x - 1σ		1.3	0.028	0.0032	0.119	0.0024	0.0022	0.0024	2.606	0.0049	0.112	0.00010	0.0168	0.0023
x + 1σ		14.0	0.035	0.0099	0.513	0.0048	0.0044	0.0267	20.219	0.0696	1.109	0.00025	0.0386	0.0068

Source: DOE, 1991b.

= Indicates concentrations not within 1σ of geometric mean.

= Chemicals of concern for which geometric means exceed potential ARAR.

= Selected sampling locations.

TABLE A-3

**SURFACE WATER
RADIONUCLIDES OF CONCERN
LOCATION AVERAGES**

Location	Potential ARAR	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Plutonium 239 & 240 (pCi/L)	Radium 226 (pCi/L)	Tritium (pCi/L)	Uranium (Total) (pCi/L)
		7.0	5.0	0.05	5	500	5.0
Station 63[a]				0.24			
Station 64[a]		26	55	0.005		200	13
Station 103[a]		26	28	0.48		244	3.9
903 Pad[a]		85	29	15		230	4.5
Station 53[a]		125	7.8	20		222	5.2
South Walnut Creek[a]		73	56	0.32		225	5.5
Station 59[a]		96	96	0.75		200	7.9
SW 084[b]		30.4	23.5	0.134	0.9		
SW 085[b]		239	166	0.57	5.5		
SW 086[b]		12	14.3	0.093	0.3		
SW 087[b]		315	424	0.144	1.4		
SW 088[b]		76.3	102.5	0.268	0.3		
SW 089[b]		532	440	20.6	2.3		
SW 090[b]		561	1,275	0.053	1.3		
SW 091[b]							
SW 094[b]		66.9	112.9	0.073	0.5		
SW 095[b]		76.4	146	0.166	0.7		
SW 102[b]		3.4	23.9	0.036			
SW 105[b]		142	459	0.033	0.6		
SW 106[b]		26	42	0.009	0.1		
Geometric Mean (x)		70.8	80.3	0.223	0.75	220	6.1
x - 1σ		19.1	20.5	0.020	0.25	203	3.9
x + 1σ		262.2	314.5	2.424	2.22	238	9.5

[a]Source: DOE, 1991b.
[b]Source: DOE, 1991c.

= Indicates concentration not within 1σ of geometric mean.
= Chemicals of concern for which geometric means exceed potential ARAR.
= Selected sampling locations.

TABLE A-4

SURFACE WATER SAMPLING LOCATION SELECTION

Location	Status as Sampling Location	Reason for Status
Station 63	Rejected	Data for several radionuclides of concern was not provided for this location
Station 64	Potentially acceptable	Alternate sampling location
Station 103	Accepted	Contains above *average concentrations* of metals; *representative* concentrations of radionuclides
903 PAD	Rejected	Results reflect multiple sampling locations
Station 53	Accepted	Contains *representative* concentrations of metals; *above average* concentrations of radionuclides
South Walnut Creek	Rejected	Results reflect multiple sampling locations
Station 59	Potentially acceptable	Alternate sampling location
SW 084	Rejected	Data for metals of concern was not provided for this location
SW 085	Rejected	Data for metals of concern was not provided for this location
SW 086	Rejected	Data for metals of concern was not provided for this location
SW 087	Rejected	Data for metals of concern was not provided for this location
SW 088	Rejected	Data for metals of concern was not provided for this location
SW 089	Rejected	Data for metals of concern was not provided for this location
SW 090	Rejected	Data for metals of concern was not provided for this location

TABLE A-4

SURFACE WATER SAMPLING LOCATION SELECTION (Concluded)

Location	Status as Sampling Location	Reason for Status
SW 091	Rejected	Data for metals of concern was not provided for this location
SW 094	Rejected	Data for metals of concern was not provided for this location
SW 095	Rejected	Data for metals of concern was not provided for this location
SW 102	Rejected	Data for metals of concern was not provided for this location
SW 105	Rejected	Data for metals of concern was not provided for this location
SW 106	Rejected	Data for metals of concern was not provided for this location

Initially, the geometric mean of location concentration averages or location activity averages was calculated for each chemical of concern. The geometric mean plus or minus one standard deviation (σ) was also calculated for each chemical of concern. Using these statistical parameters, appropriate surface water sampling locations were selected.

In selecting sampling locations, the primary intent is to select surface water locations that contain constituent concentrations considered typical of surface water expected at the full-scale treatment facility. Hence, the concern is only with the surface water samples within the population of *surface water expected at the full-scale treatment facility*.

Because there is no flow information relative to each sampling location (and no indication of whether some locations are part of the same tributary), each sampling location is assumed to represent an equal component of our population. Thus, taking the geometric mean of sampling location means is an appropriate method of estimating the "typical or average composition" of surface water expected at the full-scale treatment facility. Furthermore, selecting an individual sampling location that most closely matches this "typical composition" is practical in the sense that compositing of surface water from several sampling locations is eliminated.

Table A-4 discusses the rationale for rejecting potential sampling locations. The two surface water sampling locations selected for the Treatability Study are as follows:

- **Station 103.** Contains *above average* concentrations of most metals of concern (such as Al, As, Ba, Be, Cd, Cr, Fe, Pb, Mn, Hg, and Ni concentrations are all greater than one standard deviation above the mean) and *representative* activities of most radionuclides of concern (such as gross alpha, gross beta, plutonium, and uranium activities are within one standard deviation of the mean). Furthermore, Al,

Ba, Be, Fe, Pb, and Mn concentrations and gross alpha, gross beta, and plutonium activities are above potential ARARs.

- **Station 53.** Contains *representative* concentrations of metals of concern and *above average* activities for gross beta and plutonium. Furthermore, Al, Fe, and Mn concentrations and gross alpha, gross beta, plutonium, and uranium activities are above potential ARARs/TBCs.

A.1.1.2 Groundwater Sampling Locations

Groundwater data made available for the selection of groundwater sampling locations was contained in the 1990 Groundwater Monitoring Report for Regulated Units at the Rocky Flats Plant, Volume 1, March 1, 1991 (DOE, 1990a). This report presents analyte concentrations that were measured above established area *background exceedance values* in 1990. Measured analyte concentrations below established *background exceedance values* are not presented with the report. Hence, it is not possible to calculate average temporal concentrations at sampling locations for the identified chemicals of concern as was done for the surface water data in the previous subsection. Maximum 1990 exceedance concentrations for metals of concern are shown in Table A-5. Maximum 1990 exceedance activities for gross alpha–the radionuclide of concern within groundwater–and other radionuclides of interest, are shown in Table A-6.

Table A-7 discusses the rationale for rejecting groundwater wells as sampling locations. The two wells selected for sampling are within the Solar Evaporation Ponds Area and include the following two wells:

- Groundwater well 2886. Contains elevated (for example, above background) gross alpha activity and elevated concentrations of chromium and manganese.

- Groundwater well P210289. Contains elevated gross alpha activity and an elevated concentration of selenium.

TABLE A-5

GROUNDWATER
METALS (TOTAL) OF CONCERN
MAXIMUM EXCEEDANCE VALUES ABOVE BACKGROUND

Location		As mg/L	Cd mg/L	Cr mg/L	Fe mg/L	Pb mg/L	Mn mg/L	Se mg/L
	Potential ARAR	0.05	0.01	0.05	0.3	.05	.05	.010
	Background Exceedance Value	0.010	0.011	0.020	0.944	0.040	0.213	0.221
Solar Evaporation Ponds (OU 4)								
0260			.0220	.09270				.290
1786				.05570				
2286				.02110				
2886				.02470			.265	
3086				.05670				
3586					1.18		3.91	
3686								
5687						.170		
P207689								.462
P207889				.02048				
B208089					1.44		4.08	
B208689							.368	
P208989			.02580	.13900				
P209189							.276	
P209889			.03520	.17200				
P210289								.372
West Spray Field (OU 11)								
B410589			.02630			.103		
B410689							.414	
B110889			.01130					
B110989							.297	
B411289					4.250		1.90	
Present Landfill (OU 7)								
0686							.388	
0786					3.760			
6087						.045		
6387					13.0		6.00	
6487		.012			57.1		4.12	

TABLE A-5

GROUNDWATER
METALS (TOTAL) OF CONCERN
MAXIMUM EXCEEDANCE VALUES ABOVE BACKGROUND
(Concluded)

Location		As mg/L	Cd mg/L	Cr mg/L	Fe mg/L	Pb mg/L	Mn mg/L	Se mg/L
	Potential ARAR	0.05	0.01	0.05	0.3	.05	.05	.010
	Background Exceedance Value	0.010	0.011	0.020	0.944	0.040	0.213	0.221
6587					1.81		.584	
B106089					4.04		1.06	
B206389					5.50		2.44	
B206789								.821
B207089				.02098				
4187			.00960	.06790			.0911	.360
B207189				.02200				

Source: DOE, 1990a.
▒▒▒ = Selected sampling locations.

Table A-6

GROUNDWATER
RADIONUCLIDES OF CONCERN
MAXIMUM EXCEEDANCE VALUES ABOVE BACKGROUND

Location		Gross Alpha	Gross Beta	Plutonium 239 & 240	Radium 226	Tritium	Uranium U-233, 234	Uranium U-235	Uranium U-238
	Potential ARAR	7.0	5.0	0.03	5	500	5.0	(Total Uranium)	
	Background Exceedance Values	55.1	59.6	--	--	359	.01	2.1	25.6
Solar Evaporation Ponds									
1786						900	34.1		
2886		230	213				290	9	190
3086		103.1	76.4			4,710	107.7	3.44	70.6
P20898		76				2,440	67.9		40.7
B208689		68	65.8				73.4	2.19	48.1
P20988						7,710	35.3		
P210289		114	55				50.9		38.5

Source: 1990, Annual RCRA, Groundwater Monitoring Report for Regulated units as Rocky Flats Plant, Volume 1, March 1, 1991 (DOE, 1990a.)

= Selected sampling locations.

= Radionuclides that are not considered sitewide chemicals of concern.

TABLE A-7

GROUNDWATER SAMPLING LOCATION SELECTION

Location	Status as Sampling Location	Reason for Status
Solar Evaporation Ponds		
0260	Rejected	Gross alpha activity is below background
1786	Rejected	Gross alpha activity is below background
2286	Rejected	Gross alpha activity is below background
2886	Accepted	Contains elevated gross alpha activity and elevated concentrations of chromium and manganese
3086	Potentially accepted	Alternate sampling location
3586	Rejected	Gross alpha activity is below background
5687	Rejected	Gross alpha activity is below background
P207689	Rejected	Gross alpha activity is below background
P207889	Rejected	Gross alpha activity is below background
P207989	Rejected	Gross alpha activity is below background
B208089	Rejected	Gross alpha activity is below background
B208689	Potentially acceptable	Alternate sampling location
P20898	Rejected	Concentrations for metals of concern are below background
P20988	Rejected	Concentrations for metals of concern are below background
P209189	Rejected	Gross alpha activity is below background

TABLE A-7

GROUNDWATER SAMPLING LOCATION SELECTION (Continued)

Location	Status as Sampling Location	Reason for Status
P209189	Rejected	Gross alpha activity is below background
P209889	Rejected	Gross alpha activity is below background
P210289	Accepted	Contains elevated gross alpha activity and an elevated concentration of selenium
West Spray Field		
B410589	Rejected	Gross alpha activity is below background
B410689	Rejected	Gross alpha activity is below background
B110889	Rejected	Gross alpha activity is below background
B110989	Rejected	Gross alpha activity is below background
B411289	Rejected	Gross alpha activity is below background
Present Landfill		
0686	Rejected	Gross alpha activity is below background
0786	Rejected	Gross alpha activity is below background
6087	Rejected	Gross alpha activity is below background
6387	Rejected	Gross alpha activity is below background
6487	Rejected	Gross alpha activity is below background
6587	Rejected	Gross alpha activity is below background

TABLE A-7

GROUNDWATER SAMPLING LOCATION SELECTION (Concluded)

Location	Status as Sampling Location	Reason for Status
B106089	Rejected	Gross alpha activity is below background
B206389	Rejected	Gross alpha activity is below background
B206789	Rejected	Gross alpha activity is below background
B207089	Rejected	Gross alpha activity is below background
4187	Rejected	Gross alpha activity is below background
B207189	Rejected	Gross alpha activity is below background

A.1.1.3 Sampling Location Summary

Water from two surface water and two groundwater sampling locations shall undergo treatability study testing. Sampling locations are summarized in Table A-8. Alternate locations are also listed.

A.1.2 Sampling Procedures

Samples collected for initial analytical analysis and samples used in the Treatability Study shall be collected in accordance with Rocky Flats Plant Environmental Management Department Operating Procedures 5-21000-OPS-GW.5—Field Measurement of Groundwater Field Parameters, 5-21000-OPS-GW.6—Groundwater Sampling, 5-21000-OPS-SW.2—Field Measurement of Surface Water Field Parameters, and 5-21000-OPS-SW.3—Surface Water Sampling (EG&G, 1991). Unfiltered Treatability Study samples from each sampling location shall be collected in 12-gallon plastic U.S. Department of Transportation (DOT)-34 drums that will be completely filled to minimize head space. Approximately nine drums (for a total volume of 108 gallons collected for all samples) shall be filled at each of the four sampling locations for use in the Treatability Study. The amount of sample required for each test is based on the minimum quantity of liquid needed to perform the required analyses. Unfiltered analytical samples from each of the four sampling locations shall also be collected and submitted by sampling personnel for analysis (see Section A.4). All water samples will be filtered and analyzed before performing the treatability tests. The DOT-34 drums shall be transferred to the Treatability Study Laboratory using chain-of-custody (COC) procedures (see Section A.6), following all required U.S. Environmental Protection Agency (EPA), and DOT regulations. Analytical samples shall be shipped to an analytical laboratory also using appropriate COC procedures (see Section A.6).

A.2 FIELD MEASUREMENT

Various indicator parameters (pH, oxidation reduction potential, dissolved oxygen, temperature and specific conductivity) will be measured in groundwater and surface water samples. These

TABLE A-8

SUMMARY OF SAMPLING LOCATIONS

	Sample Location
Groundwater	
Sample 1	Well 2886
Sample 2	Well P210289
Alternates	Wells 3086 and B208689
Surface Water	
Sample 1	Station 103
Sample 2	Station 53
Alternates	Stations 59 and 64

Note: Twelve 12-gallon containers of incoming water will be collected for this treatability study, consisting of three 12-gallon containers from each of the four sampling locations. The samples that will be sent out for pretreatment testing will be collected by making a composite sample of each of the twelve 12-gallon water samples.

measurements will be taken at each sampling event and sampling location. This section describes the procedures to be followed for field measurements.

A variety of equipment will be used during the field monitoring of water sample for subsequent use in the Treatability Study. Field equipment shall be calibrated and maintained per manufacturers' recommendations. Calibration procedures for each piece of field equipment shall be documented in the field log book.

A.3 FIELD DATA DOCUMENTATION AND PROCEDURES

Documentation of observations and data acquired in the field will provide a permanent record containing information on the handling and preparation of samples collected.

Field Data Documentation Procedures shall be consistent with the Rocky Flats Plant Environmental Management Department EMD OPS FO.13 titled, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples (EG&G, 1991). The applicable section from EMD OPS FO.13 Section 6.4 is addressed below.

A.3.1 Field Data Forms

All field descriptions, measurements, and observations shall be recorded on the appropriate field data form in accordance with FO.2, Field Document Control (EG&G, 1991). The original data forms shall be collected and filed on site by the subcontractor's designated data entry personnel. These forms are to be bound and submitted to EG&G accompanied by a transmittal letter on a monthly schedule for the entire duration of the task. This form is an example of data entries required for the Rocky Flats Environmental Data System (RFEDS) database. Data may also be recorded in field logbooks if desired. Field data will be filled out at the time a sample is taken and shall include, but not be limited to, the following information:

- Sampling activity name and number

- Sampling point name and number
- Sample number[1]
- Name(s) of collector(s) and others present[1]
- Date and time of sample collection[1]
- Sample container tag number (if appropriate)[1]
- Preservative(s) used[1]
- Requested analyses[1]
- Sample matrix[1]
- Filtered/unfiltered[1]
- Designation of QC Samples (Only for MS and MSD)[1]
- Collection methods
- Chain of custody control numbers
- Field observations and measurements during sampling (comment section)
- Signature of responsible observer

A.3.2 Field Log

Bound and consecutively numbered Field Logs shall be maintained by sampling personnel at all times. All entries shall be made with indelible ink and signed and dated each day. Records shall contain sufficient information so that someone can reconstruct the activity in the absence of the person who took the notes.

A field log book shall be developed and maintained, and will contain the following information:

- Name and title of author, data and time of entry
- Personnel involved in activities
- Specific data collected

[1]Items to be documented on the COC form.

If an error is made in a Field Log assigned to an individual, that individual shall make corrections simply by crossing a line through the error and entering the correct information. The erroneous information shall not be obliterated. Any subsequent error discovered in a Field Log shall be corrected by the person who made the entry. All data corrections shall be initialed and dated.

A.4 SAMPLE CONTAINERS, VOLUMES, PRESERVATIVES, AND HOLDING TIMES

Collected groundwater and surface water samples shall be sent to the laboratory for subsequent analysis and/or use in the treatability study. Sample containers, volumes, preservatives, and holding times associated with samples collected for analysis shall be consistent with the Rocky Flats Plant Environmental Management Department EMD OPS FO.13 titled, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples. Applicable sections from EMD OPS FO.13 Sections 6.0 and 6.1 are addressed below (EG&G, 1991).

A.4.1 Procedures

Procedures for the containerizing and preserving water samples follow strict criteria of the EPA's Contract Laboratory Program (CLP). Information presented herein is intended to present general guidelines for proper sample handling, and any deviations or modifications will be documented in the Scope of Work or specific Task Order.

A.4.2 Sample Containers and Preservatives

Only sample containers certified as clean by the manufacturer will be used for sample collection. The containers and preservatives may be obtained from the contracted analytical laboratory, their designated supplier, or a suitable chemical supply company. Any preservative(s) required may be added to the container by the contracted analytical laboratory, field sample team, sample manager, and/or onsite chemist prior to or during sample collection.

Table A-9 lists parameters of interest and associated container size, preservatives (chemical and/or temperature), and holding times. Table A-10 lists analytical methods and detection limits for parameters of interest.

A.5 SAMPLE DESIGNATION SYSTEM

A sample designation system shall be used to identify each sample collected during the field sampling effort. The sample designation system shall provide a tracking procedure to allow retrieval of information about a particular sample and shall be consistent with the Rocky Flats Plant Environmental Management Department EMD OPS FO.13 titled, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples (EG&G, 1991). The applicable section from EMD OPS FO.13 (Section 6.2) is addressed below.

A.5.1 Container Labeling and Decontamination

Prior to sample collection, sample bottles shall be labeled by the sample manager or an assistant. Collection time and date shall be marked in the field by the sampler. The labels shall indicate:

- Activity name and/or number
- Unique sample number
- Sampling time and date
- Chemical preservative used
- Sample type (grab, composite)
- Analyses required
- Filtered/unfiltered
- Comments or special precautions, as needed
- Samplers Initials

The sample label shall be marked with a black waterproof pen. If needed, clear tape will be placed over labels before sampling to assure that the labels remain legible.

TABLE A-9

SAMPLE CONTAINERS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES FOR TARGET COMPOUND AND TARGET ANALYTE LISTS

WATER MATRIX

Parameter	Container	Preservative	Holding Time
Liquid - Low to Medium Concentration Samples			
Inorganic Compounds			
Metals (TAL)	1 x 1-L polyethylene bottle	Nitric acid, pH<2	6 mo[a]
Alkalinity	200 ml/P,G	Cool, 4°C	14 days
Chromium, Hexavalent	200 ml/P,G	Cool, 4°C	24 hours
Radiological tests[b]	12.0 l-plastic[c]	HNO_3	6 months
Tritium	125 ml glass	None	None
Chloride	200 ml/P,G	None	28 days
Nitrate and Nitrite	125 ml glass	H_2SO_4	28 days
Nitrate	125 ml glass	None	48 hours
Sulfates	500 ml/P,G	Cool, 4°C	28 days
Total Dissolved Solids	200 ml/P,G	None	7 days

[a]Holding time for mercury is 28 days.
[b]For Radiological Testing, the specific analyses will be defined as some or all of the following, as specified in Section 5.0; gross alpha, gross beta, uranium 233+234, 235 and 238, plutonium 239+ 240, tritium, and radium 226.
[c]Full suite.

Abbreviations: P—Plastic
G—Glass

Note: When nonspecific container type is listed (such as an, 8-oz wide-mouth glass jar), select a container appropriate to the volume and container requirement given. Samples for more than one parameter can be collected into a single container if container and preservation requirements are the same (such as, sulfate and turbidity).

TABLE A-10

ANALYTICAL METHODS AND DETECTION LIMITS

Parameter	Method	Level[a]	Detection Limit, µg/l (unless noted otherwise)
Aluminum	CLP	4	200
Antimony	CLP	4	60
Arsenic	CLP	4	10
Barium	CLP	4	200
Beryllium	CLP	4	5
Cadmium	CLP	4	5
Chromium, total	CLP	4	10
Chromium, hexavalent	EPA218.5	5	
Iron	CLP	4	100
Lead	CLP	4	3
Manganese	CLP	4	15
Mercury	CLP	4	0.2
Nickel	CLP	4	40
Selenium	CLP	4	5
Chloride	EPA325	3	5 mg/L
Nitrate and Nitrite	EPA353.1	3	0.1 mg/L
Nitrate	EPA352.1	3	0.1 mg/L
Sulfate	EPA375.4	3	5 mg/L
Total Dissolved Solids	EPA160.1/160.2	3	10 mg/L
Gross Alpha	SW846/9310	4	3 pCi/L
Gross Beta	SW846/9310	4	4 pCi/L
Plutonium 239+240	EMSL-LV-0539-17	4	0.2 pCi/L
Tritium	EMSL-LV-0539-17	4	1 pCi/L
Uranium 233/234/235/238	EMSL-LV-0539-17	4	0.2 pCi/L

[a]EPA base method references are provided here. Refer to EG&G, Rocky Flats' GRRASP, Version 2.1 (DOE, 1991) document for the exact methods and detection limits.

Subsequent to sampling, the exterior of the sample containers shall be decontaminated (according to EMD OPS FO.3, General Equipment Decontamination), (EG&G, 1991), placed in plastic bags, and put in coolers dedicated for sample and sample container transportation. The temperature in the coolers shall be maintained at approximately 4°C by adding sealed plastic bags containing blue ice (or an equivalent) to the coolers.

During the initial stages of field work, the sample manager shall use a thermometer to verify the an adequate amount of blue ice is being used to maintain sample temperature at approximately 4°C.

A.6 SAMPLE CUSTODY

A required part of this sampling and analytical program is the integrity of the sample from collection to data reporting. This includes the ability to trace the possession and handling of samples from the time of collection, through analysis, to final deposition. The documentation of the samples' history is referred to as "chain-of-custody." Sample custody procedures shall be consistent with the Rocky Flats Plant Environmental Management Department EMD OPS FO.13 titled, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples. The applicable section from EMD OPS FO.13 (Section 6.3) is addressed below (EG&G, 1991).

A.6.1 Chain of Custody Record

Official custody of samples shall be maintained and documented from the time of collection until the time that valid analytical results have been obtained or the laboratory has been released to dispose of the sample. The sampling team shall be responsible for initiating the original chain of custody (COC) form and shall sign and date this form when relinquishing custody of samples to the sample manager. Upon receipt, the sample manager shall check the COC and all sample labels to ensure that all samples are accounted for and in good condition, and that no errors where made in labeling and/or completing the COC.

A sample is considered to be in a person's custody if any of the following conditions are met:

- The sample is in the person's physical possession.
- The sample is in line of sight of the person after he/she has taken possession.
- The sample is secured by that person so that any tampering can be detected.
- A sample is secured by the person in possession in an area which only authorized personnel can enter.

A.6.2 Chain of Custody Form

A three-page carbonless COC form shall be used for all sample shipments. The original and second (yellow) copy shall be included with the samples to be shipped enclosed in a plastic bag and taped inside the lid of the cooler. The third (pink) copy along with a photocopy of the original shall remain on file at the subcontractors on-site facility. The contract laboratory shall sign as having received the samples and return the yellow copy of the COC to the project management office for verification by the QA/QC officer or their designee. The yellow and pink copies shall then be matched and filed to complete the chain of custody procedure.

The chain of custody form shall include the following information:

- Unique sample number and sample location
- Project number
- Date and time of sample collection
- Signature of collector or field custodian
- Laboratory designation
- Sample matrix
- Condition of sample on receipt at the laboratory

- Chain of custody control number
- Signature and date blocks for personnel relinquishing or receiving sample custody
- Space for additional comments
- Name and phone number of emergency contact person
- Analysis requested
- Out of spec reporting

A.6.3 Custody Seals

Custody seals are used to detect unauthorized handling of samples following collection, up to the time of analysis. Items such as gummed paper seals and custody tape may be used for this purpose. The seal shall be of the type that when attached to the container it will break when the container is opened. Seals shall be affixed to each sample container (for example each bottle) before the samples leave the custody of the sampling personnel.

Shipping containers (such as coolers) shall also contain at least two custody seals to detect possible tampering. Clear tape should be placed over the seals to ensure that seals are not accidently broken during shipment. A seal shall include the following information:

- Sampler's signature
- Date of collection

A.6.4 Tampering of Sampling Containers

If, at any time after samples have been secured, custody seals are identified as having been tampered with, this procedure shall be followed to ensure that sample integrity has not been compromised.

- Check cooler temperature to verify 4°C.

- Check with all personnel having access to sample coolers to verify possible inadvertent tampering.

- Check every sample container for any signs of tampering, such as loose lids, foreign objects in containers, broken or leaking containers.

- Check to ensure adequate and appropriate packaging.

- Document all findings of the incident in the sample manager's Field Log.

If it is determined that malicious tampering of samples has occurred and/or it is believed that sample integrity has been compromised, the subcontractor shall immediately contact EG&G.

If it can be determined that sample integrity has not been compromised based on the above criteria, document findings in sample manager's Field Log and proceed with standard operating procedures.

A.7 SAMPLE PACKING AND SHIPPING

Packing and shipping of samples shall be consistent with the Rocky Flats Plant Environmental Management Department EMD OPS FO.13 titled, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples (EG&G, 1991). Applicable sections from EMD OPS FO.13 (Sections 5.1, 5.2, and 6.5) are addressed below.

A.7.1 Equipment List

The following list of equipment is not intended to be task specific. The equipment and materials shown are the minimum that may be needed to ensure that proper procedures are followed for sample handling, packaging, and shipping.

- Sample containers/bottles

- Coolers
- Thermometer
- Blue ice
- Sample labels
- COC forms
- Decontamination equipment[2]
- Preservatives
- Baggies for containers
- Bubble wrap
- Vermiculite or equivalent
- Strapping and clear tape
- Custody seals
- Garbage bags
- Metal paint cans[3]

A.7.2 Department/Office Contact List

EG&G or its designee is responsible for obtaining the appropriate documentation for radiation (RAD) screening, and monitoring of all field samples for shipment off site.

The following departments will need to be contacted before sample shipment.

- **Construction Management Coordinator**--To obtain property passes for shipment of materials off site

[2]Decontamination equipment and procedures are thoroughly discussed in the General Equipment Decontamination EMD OPS FO.13 (EG&G, 1991).

[3]Large enough to accommodate sample containers.

- **Radiation Site Survey Office**—For radiation monitoring and clearance of off site shipment of coolers

- **Onsite General Laboratories**—For radiological screening and categorization of field samples

A.7.3 Packaging and Shipping

Prior to commencement of field activities, estimated levels of chemical and/or radiological contaminants shall be determined from known historical data for all matrices to be sampled by EG&G or its designee. Three levels of contaminant concentrations are defined as follows:

- **Low-Concentration Samples**—The contaminant of highest concern is present at less than 10 parts per million (ppm). Examples include background environmental samples.

- **Medium-Concentration Samples**—The contaminant of highest concern is present at a level grater than 10 ppm and less than 15 percent (150,000 ppm). Examples include material that is obviously weathered.

- **High-Concentration Samples**—At least one contaminant is preset at a level greater than 15 percent. Samples from drums and tanks are assumed to be high concentration unless information indicates otherwise.

RAD screening of field samples shall be performed by EG&G at the Onsite General Laboratory. The RAD screening shall procedures determine which laboratory receives samples based on results of greater than (GT) *or* less than (LT) 50 picocuries/liter for water samples. The RAD screening procedures also enable the subcontractor to follow applicable DOT guidelines for shipment of these environmental samples.

All sample containers will have been decontaminated and bagged in the field. Upon receipt and verification of sample containers and COC forms, the following steps shall be taken:

- The designated laboratory will be notified prior to shipment if samples collected in the field are suspected of containing any other substance for which the laboratory personnel should take additional safety precautions.
- Contact the Radiation Site Survey Office so that all containers to be shipped off site can be radiologically cleared.
- Obtain Property Passes signed by the Construction Management Coordinator and the Radiation Site Survey Officer so that coolers may be shipped off site.
- Line sample cooler with a large plastic bag.
- Place approximately 3 inches of vermiculite in the bottom of the cooler.
- Wrap glass containers in bubble pack.
- Verify that all samples requiring screening have reported estimated radiological activity levels.
- Place bagged and wrapped sample containers upright in the cooler with approximately 1 inch between them.
- Fill the cooler approximately three-quarters full of vermiculite, making sure that sample containers are securely packed.
- Fill the cooler with vermiculite, allowing adequate space at the top for blue ice.

- Bag the blue ice (or equivalent) and place several packages in the top space of the cooler[4].

- Seal the signed COCs in a plastic bag and tape it to the underside of the lid of the cooler.

- Tape the drain of the cooler shut.

- Wrap strapping tape around the cooler in two locations to secure the lid.

- Place the air bill on top of the cooler. If more than one cooler is sent to the same laboratory, an address label and a manifest label are needed.

- Place "This Side Up" labels on all four sides and "Fragile" labels on the top and two sides of the cooler.

- Place an "Environmental Samples" label on top of cooler. For coolers over 75 pounds, an additional "Heavy Weight" label is required in the top, upper left corner of the cooler.

- Place signed and dated custody seals in two locations to seal the cooler lid so that tampering will be evident.

The following steps shall be taken for samples estimated to contain both medium and/or high level concentrations:

- Enclose all sample containers in clear plastic bags.

[4]See Tables A-1 and A-2 of this section for parameters requiring 4°C $\pm$ 2°C.

- Pack all medium and high level water and soil samples in metal paint cans.
- Label paint cans with sample number of sample contained inside.
- Surround contents of can with non-combustible, absorbent packing material.
- Use freezer package cool samples to 4°C.
- Pack sealed paint cans or plastic-enclosed sample bottles in shipment container.
- Use a metal ice chest for shipment (do *not* use cardboard or styrofoam containers to ship samples).
- Surround contents with non-combustible, absorbent packing material (do *not* use earth or ice packing materials).
- Tape paper work in plastic bags under cooler lid.
- Close cooler and seal with custody seals.

Sample coolers may be received by courier at a predetermined area at the Rocky Flats Plant. If arrangement cannot be made, a company vehicle is required to deliver sample coolers to the laboratory and/or courier office.

A.7.4 Air Bills and Bills of Lading

If samples are sent by mail, the package shall be registered with return receipt requested. If sent by common carrier, a bill of lading or air bill shall be used. Freight bills, Postal Service receipts, and bills of lading shall be retained as part of the field files.

APPENDIX B. REACTION EQUATIONS

B.1 GENERAL COMMENTS–TASKS 2, 3, AND 4

- Only equations for primary target analytes are provided.
- Non involved ions are not shown in the equations.
- Ions and compounds are assumed to be dissolved in the aqueous phase unless an ↓ is shown, indicating the compound precipitates out of solution.
- In aqueous solution, plutonium can be in any of four oxidation states (+3 to +6), which can interconvert by disproportionation. The +3 oxidation state is the most stable at neutrality and +4 is most stable at low acidity, so +3 or +4 is taken as the reaction product of chemical reduction of the +4, +5, and +6 states, as appropriate for the reaction conditions.

B.1.1 Task 2–Ferrous Sulfate Reduction

Target analytes are chromium, mercury, and plutonium.

$$3Fe^{2+} + CrO_4^{2-} + 4\ OH^- + 4H_2O \rightarrow 3Fe(OH)_3 \downarrow + Cr(OH)_3 \downarrow$$

$$2Fe^{2+} + 2Hg^{2+} + 8OH^- \rightarrow 2Fe(OH)_3) \downarrow + Hg_2(OH)_2 \downarrow$$

$$3Fe^{2+} + PuO_2^{2+} + 5OH^- + 2H_2O \rightarrow 3Fe(OH)_3 \downarrow + Pu^{3+}\ (\text{adsorption}) \downarrow$$

$$2Fe^{2+} + PuO_2^{+} + 2OH^{-} + 2H_2O \rightarrow {}_2Fe(OH)_3\downarrow + Pu^{3+}\ (\text{adsorption})\downarrow$$

$$Fe^{2+} + Pu^{4+} + 3OH^{-} \rightarrow Fe(OH)_3\downarrow + Pu^{3+}\ (\text{adsorption})\downarrow$$

Dissolved oxygen provides a competing reaction.

$$4Fe^{2+} + O_2 + 8OH^{-} + 2H_2O \rightarrow 4Fe(OH)_3\downarrow$$

B.1.2 Task 3–Sodium Bisulfite Reduction

Target analytes are chromium, mercury, and plutonium.

$$3HSO_3^{-} + 2CrO_4^{2-} + H_3O^{+} \rightarrow 3SO_4^{2-} + 2Cr(OH)_3\downarrow$$

$$2HSO_3^{-} + 2Hg^{2+} + 5H_2O \rightarrow SO_4^{2-} + Hg_2SO_3\downarrow + 4H_3O^{+}$$

$$HSO_3^{-} + PuO_2^{2+} + H_3O^{+} \rightarrow SO_4^{2-} + Pu^{4+} + 2H_2O$$

$$HSO_3^{-} + 2PuO_2^{+} + 5H_3O^{+} \rightarrow SO_4^{2-} + 2Pu^{4+} + 8H_2O$$

Dissolved oxygen provides a competing reaction.

$$2HSO_3^{-} + O_2 + 2H_2O \rightarrow 2SO_4^{2-} + 2H_3O^{+}$$

B.1.3 Task 4–Stannous Chloride Reduction

Target analytes are chromium, mercury, and plutonium

$$3SnCl_4^{2-} + 2CrO_4^{2-} + 6Cl^{-} + 10H_3O^{+} \rightarrow 3SnCl_6^{2-} + 2Cr(OH)_3\downarrow + 12H_2O$$

$$SnCl_4^{2-} + 2Hg^{2+} + 4Cl^- \rightarrow SnCl_6^{2-} + Hg_2Cl_2 \downarrow$$

$$SnCl_4^{2-} + PuO_2^{2+} + 2Cl^- + 4H_3O^+ \rightarrow SnCl_6^{2-} + Pu^{4+} + 6H_2O$$

$$SnCl_4^{2-} + 2PuO_2^{+} + 2Cl^- + 8H_3O^+ \rightarrow SnCl_6^{2-} + 2Pu^{4+} + 12H_2O$$

Dissolved oxygen provides a competing reaction.

$$2SnCl_4^{2-} + O_2 + 4Cl^- + 4H_3O^+ \rightarrow 2SnCl_6^{2-} + 6H_2O$$

B.2 GENERAL COMMENTS–TASKS 5, 6, 7, AND 8

Coprecipitation occurs when ions are trapped by a salt that is precipitating. This can occur either by adsorption onto the crystal lattice or by being physically trapped within a rapidly growing crystal. Individual coprecipitation equations are not included.

Addition of water treatment polymers to the solution provides locations for charged colloids to adsorb and enhances the removal of the ions.

B.2.1 Task 5–Barium Sulfate Coprecipitation

$$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4 \downarrow$$

B.2.2 Task 6–Lime Precipitation

Several constituent-specific chemical reactions occur during Task 6. The reaction of naturally occurring iron is representative.

$$2Fe^{2+} + O_2 + 2OH^- + 2H_2O \rightarrow 2Fe(OH)_3 \downarrow$$

B.2.3 Task 7—Iron Coprecipitation

For steps 1 through 4, the reaction is as follows.

$$Fe^{3+} + 3OH^- \rightarrow Fe(OH)_3 \downarrow$$

B.2.4 Task 8—Alum Coprecipitation

$$Al_2(SO_4)_3 + 6OH^- \rightarrow 2Al(OH)_3 \downarrow + 2SO_4^{2-}$$

B.3 GENERAL COMMENTS—TASK 9

The "competing reactions" with dissolved oxygen (Tasks 2, 3, and 4) are related to air oxidation. Bubbling air through the solution replenishes the dissolved oxygen.

B.3.1 Task 9—Air Oxidation

$$2Mn^{2+} + O_2 + 6H_2O \rightarrow 2MnO_2 \downarrow + 4H_3O^+$$

$$4Fe^{2+} + O_2 + 8OH^- + 2H_2O \rightarrow 4Fe(OH)_3 \downarrow$$

APPENDIX C. SAMPLE HEALTH AND SAFETY PLAN

The following section is a sample of the health and safety plan. When the laboratory contractor is selected, this contractor will develop a detailed site-specific health and safety plan for the work to be performed.

HEALTH AND SAFETY PLAN

This health and safety plan (HSP) is an example HSP. A HSP will be kept onsite during field activities and will be reviewed and updated as necessary.

1.0 PROJECT INFORMATION AND DESCRIPTION

CLIENT OR OWNER: **PROJECT NO:**

PROJECT MANAGER: **OFFICE:**

SITE NAME: Rocky Flats Plant

SITE ADDRESS: Golden, CO

DATE HEALTH AND SAFETY PLAN PREPARED:

DATE(S) OF INITIAL VISIT:

DATE(S) OF SITE WORK:

SITE ACCESS:

LOCATION:

The Rocky Flats Plant (RFP) site is located in northern Jefferson County approximately 16 miles northwest of Denver. It is comprised of 6,550 acres of federally owned land. Major administrative and manufacturing buildings are located within RFP security area of 400 acres. The remaining 6,150 acres comprise the buffer zone surrounding RFP complex.

SITE OPERATIONS:

The RFP is a government owned, contractor-operated facility, which is part of the nationwide nuclear weapons production complex. EG&G Rocky Flats, Inc. became the prime contractor at RFP on January 1, 1990, and is the existing contractor to date. RFP fabricates nuclear weapon components from plutonium, uranium, and other nonradioactive materials (principally beryllium and stainless steel).

THIS PAGE RESERVED FOR SITE MAP

NOTE LOCATIONS OF SUPPORT, DECONTAMINATION, AND EXCLUSION ZONES; SITE TELEPHONE; FIRST AID STATION

2.0 PROJECT ORGANIZATION AND TASKS TO BE PERFORMED UNDER THIS PLAN

2.1 PROJECT ORGANIZATION

2.2 DESCRIPTION OF TASKS

The treatability study objective is to investigate bench scale testing of oxidational reduction processes of different types to remove metals and radionuclides from surface and groundwater at Rocky Flats Plant (RFP) site. Groundwater samples and surface water samples will be collected. No new wells will be drilled.

Bench scale testing will be conducted in an onsite laboratory. The following techniques would be tested for the treatability study:

1. Oxidation/precipitation
2. Stannous chloride reduction
3. Sodium bisulfite reduction
4. Ferrous sulfate reduction

Each oxidation/reduction technique will be followed by pH adjustment and/or precipitation/ coprecipitation and filtration.

3.0 HAZARD EVALUATION AND CONTROL

3.1 HEAT AND COLD STRESS

3.1.1 GUIDELINES FOR WORKING IN TEMPERATURE EXTREMES WHILE WEARING PERSONAL PROTECTIVE EQUIPMENT (PPE)

Temperature	Work Cycle	Rest Cycle	Control Measures
<32° F or <55° F & raining	2 hrs	15 min	Review cold stress in safety meeting. Rest in a warm area. Drink at least 8 ounces of warm non-caffeinated, non-alcoholic beverage at each rest break. Schedule a mid-day lunch break of at least 30 minutes in a warm area to begin not later than 5 hours after startup.
72° to 77° F	2 hrs	5 min	Review heat stress in safety meeting. Take resting pulse rate before beginning work. Drink 8 ounces of cool water before beginning work, and 4 ounces at rest break. Have ice available.
77° to 82° F	2 hrs	5 min	As above, but seated rest break. Monitor pulse rate. (See below.)
82° to 87° F	60 min	15 min	As above, but rest area to be shaded.
87° to 90° F	30 min	15 min	As above. Try to provide a shaded work area.
>90° F	15 min	15 min	As above. Provide a shaded area with seats in the work area for team members to use as needed. Try to reschedule work to avoid mid-day heat.

PULSE CRITERIA. Take resting radial (wrist) pulse at start of work day; record it. Measure radial pulse for 30 seconds as rest period begins. Pulse not to exceed 110 beats per minute (bpm), or 20 bpm above resting pulse. If pulse exceeds this criteria, reduce work load and/or shorten the work cycle by one third, and observe for signs of heat stress. No team member is to return to work until his/her pulse has returned to <110 bpm, or resting pulse +20 bpm.

3.1.2 SYMPTOMS AND TREATMENT OF HEAT AND COLD STRESS

Heat Stroke	Heat Exhaustion	Frostbite	Hypothermia
Red, hot, dry skin; dizziness; confusion; rapid breathing and pulse; high body temperature.	Pale, clammy, moist skin; profuse sweating; weakness; normal temperature; headache; dizzy; vomiting.	Blanched, white, waxy skin, but tissue resilient; tissue cold and pale.	Shivering, apathy, sleepiness; rapid drop in body temperature; glassy stare; slow pulse; slow respiration.
Cool victim rapidly by soaking in cool (not cold) water. Get medical attention immediately!!	Remove victim to a cool, air conditioned place. Loosen clothing, place in head low position. Have victim drink cool (not cold) water.	Remove victim to a warm place. Rewarm area quickly in warm (not hot) water. Have victim drink warm fluids--not coffee or alcohol. Do not break any blisters. Elevate the injured area and get medical attention.	Remove victim to a warm place. Have victim drink warm fluids--not coffee or alcohol. Get medical attention.

3.2 PHYSICAL (SAFETY) HAZARDS AND CONTROLS (REFERENCE STANDARD OF PRACTICE [SOP])

Hazard	Engineering or Administrative Controls
Flying debris/objects	Provide shielding and PPE.
Noise > 85 dBA	Noise protection and monitoring required.
Steep terrain/unstable surface	Brace and shore equipment.
Build-up of explosive gases	Provide 20 lb A,B,C fire extinguisher and ventilation.
Build-up of static electricity	No spark sources within 50 feet of an excavation, heavy equipment, or UST removal. Ground as appropriate.
Gas cylinders	Make certain gas cylinders are properly anchored and chained. Keep cylinders away from ignition sources.
High pressure hose rupture	Check to see that fitting and pressurized lines are in good repair before using.
Electrical shock	Make certain third wire is properly grounded. Do not work on electrical wiring unless qualified to do so.
Suspended loads	Work not permitted under suspended loads.
Moving vehicles	Back-up alarm required for heavy equipment. Observer remains in contact with operator and signals safe back-up. Personnel to remain outside of turning radius.
Overhead electrical wires	Heavy equipment (e.g. drill rig) to remain at least 15 feet from overhead powerline for powerlines of 50 kV or less. For each Kv > 50 increase distance 1/2 foot.
Buried utilities, drums, tanks, and so forth.	Locate buried utilities, drums, tanks, etc. prior to digging or drilling and mark location.
Slip, trip, fall hazards due to muddy work areas	Use wood pallets or similar devices in muddy work areas.
Back injury	Use proper lifting techniques, or provide mechanical lifting aids.
Confined space entry	Permit and safety plan required.
Trenches/excavations	Make certain trench meets OSHA standard before entering. All excavations > 5 feet deep must be sloped or shored. Excavations > 4 feet deep must have a ladder every 25 feet. If not entering trench, remain 2 feet from edge of trench at all times.
Protruding objects	Flag visible objects.

3.3 TICK BITES, LYME DISEASE, AND ROCKY MOUNTAIN SPOTTED FEVER (RMSF)

Check often for tick bites. If bitten, carefully remove tick with tweezers, making certain to remove pincers, being careful not to crush the tick. After removing the tick, wash your hands. Disinfect area, and dress. If the tick resists or cannot be completely removed, seek medical attention.

Look for symptoms of lyme disease or RMSF. Lyme: rash that looks like a "bulls-eye", with small welt in center, several days to weeks after tick bite. RMSF: Rash comprising red spots under skin, 3 to 10 days after tick bite. For both, chills, fever, headache, fatigue, stiff neck, bone pain. If symptoms appear, seek medical attention.

3.4 RADIOLOGICAL HAZARDS AND CONTROLS

Exposure to ionizing radiation can cause cancer. However, recognizing the risks from radiation, recommendations for working with radioactivity and exposures to members of the public have been issued by the International Commission on Radiological Protection (ICRP) and the U.S. National Council on Radiation Protection and Measurements (NCRP). Furthermore, these recommendations have been promulgated into standards and regulations by the EPA, the U.S. Nuclear Regulatory Commission (Chapter 10 of the Code of Federal Regulations), and the Occupational Safety and Health Administration (OSHA; Chapter 29 of the Code of Federal Regulations). For work related to DOE sites, the DOE has issued Orders providing criteria for protection of health and safety and the environment. The basis of the recommendations on radiation by the ICRP and NCRP is to minimize radiation exposures and to develop criteria to ensure that the risks to radiation workers are equal to or less than those in the safety industries. The general basis for the criteria for radiation exposures to the general population is a factor of 10 or more reduction below occupational exposures, plus ensuring that the risk from the exposures is less than the risks to which people are exposed to in normal life (ICRP 26 and NCRP 91).

3.5 HAZARDS POSED BY CHEMICALS BROUGHT ONSITE

The Project Manager is to request Material Safety Data Sheets (MSDSs) from the client, or contractors and subcontractors for chemicals that employees are potentially exposed to.

Chemical	Location
Ferric chloride hexahydrate	Treatability Laboratory
Sulfite nonahydrate	Treatability Laboratory
Aluminum sulfate, hydrated	Treatability Laboratory
Calcium hydroxide	Treatability Laboratory
Hydrochloric acid, concentrated	Treatability Laboratory
Anionic, cationic, and nonionic	Treatability Laboratory
Water treatment polymers	Treatability Laboratory

3.6 OCCUPATION EXPOSURE TO HAZARDOUS CHEMICALS IN LABORATORIES

A laboratory chemical hygiene program will be established according to OSHA 29 CFR 1910.1450.

3.7 KNOWN CONTAMINANTS OF CONCERN

Contaminant	Location and Highest Concentration (solid media: mg/kg or liquid media: ug/l)	PEL, REL, or TLV (ppm)	IDLH (ppm)	Symptoms and Effects of Exposure	PIP
Aluminum					
Arsenic					
Barium					
Beryllium					
Cadmium					
Chromium					
Iron					
Lead					
Manganese					
Mercury					
Nickel					
Selenium					
Plutonium					
Radium					
Uranium					

Note 1: Lower value of PEL, REL, or TLV listed.
Note 2: NL = no limit found in reference materials.
Note 3: PIP = photoionization potential
Note 4: Location refers to physical location. Abbreviations specify media:
A (AIR) D (DRUMS) F (FLYASH) GW (GROUNDWATER) L (LAGOON) TK (TANK)
S (SOIL) SL (SLUDGE) SW (SURFACE WATER)

3.8 POTENTIAL ROUTES OF EXPOSURE

DERMAL:	INHALATION:	OTHER:
All	All	Puncture wound and ingestion; all

4.0 PERSONNEL

4.1 EMPLOYEES MEDICAL AND TRAINING REQUIREMENTS

Personnel must meet the medical surveillance, 40-hour initial training, 3-day on-the-job experience, and 8-hour annual refresher training requirements of OSHA 29CFR1910.120. Copies of training and medical certifications will be kept by the project health and safety officer. Employees designated "SSC" have received 8 hours of supervisor and 8 hours of instrument training and can serve as site safety coordinator (SSC) for the level of protection indicated. There must be one SSC present during any task performed in exclusion or decontamination zones with the potential for exposure to safety and health hazards. Employees designated "FA-CPR" are currently certified by the American Red Cross, or equivalent, in first aid and CPR. There must be one FA-CPR designated employee present during any task performed in exclusion or decontamination zones with the potential for exposure to safety and health hazards. The "buddy system" requirements of OSHA 29CFR1910.120 are to be met at all times.

Employee Name	Office	Responsibility	SSC/FA-CPR
		Field Team Leader	
		Site Safety Coordinator	Level ( ) SSC; FA-CPR

4.2 HEALTH AND SAFETY AND FIELD TEAM CHAIN OF COMMAND AND PROCEDURES

4.2.1 CLIENT

4.2.2 CONTRACTOR

4.2.3 SUBCONTRACTOR

5.0 PERSONAL PROTECTIVE EQUIPMENT (PPE) SPECIFICATION[1] (REFERENCE STANDARD OF PRACTICE)

Task	Level	Body	Foot	Head[2]	Eye	Hand	Respirator
Groundwater and surface water sampling	D	Cotton coveralls on tyveks	Neoprene steel-toed boots	Hardhat	Safety glasses and side shields, splashproof goggles	Depends on contaminants	None required
Laboratory analysis	D	Laboratory coat or rubber apron	Street shoes		Splashproof goggles	Latex gloves	None required
Groundwater and surface water sampling	C	Tyveks or saranex or PVC-coated coveralls	Neoprene steel-toed boots with latex covers	Hardhat	Safety glasses with side shields or splashproof goggles	Depends on contaminants	APR, full face, MSA Ultratwin or equivalent, cartridges:
Groundwater and surface water sampling	B	Saranex coveralls or PVC-coated coveralls	Neoprene steel-toed boots with latex covers	Hardhat	Safety glasses with side shield or splashproof goggles	Depends on contaminants	Positive pressure demand SCBA: MSA Ultralite or equivalent

Note 1: Modifications:
Note 2: The SSC shall specify hardhat areas.

5.1 REASONS TO UPGRADE OR DOWNGRADE LEVEL OF PROTECTION

Upgrade	Downgrade
• Request of individual performing task. • Change in work task that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels (Section 6.0) exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that decreases the hazard. • Change in work task that will reduce contact with hazardous materials.

6.0 AIR MONITORING EQUIPMENT SPECIFICATION (REFERENCE CH2M HILL SOP HS-06)

Instrument	Tasks	Action Levels		Frequency	Calibration
Photoionization Detector (PID):	Groundwater and surface water sampling	0 to 1 ppm[ab4] 1 to 5 ppm[ab] 5 to 50 ppm[ab] > than 50 ppm[ab]	Level D Level C Level B Stop work; re-evaluate	Prior to purging well	Daily
Flame Ionization Detector (FID): OVA-128	Groundwater and surface water sampling	0 to 1 ppm[ab] 1 to 5 ppm[ab] 5 to 50 ppm[ab] > than 50 ppm[ab]	Level D Level C Level B Stop work; re-evaluate	Prior to purging well	Daily
Radiation Meter: Alpha Scintillation Detector	Groundwater and surface water sampling and in treatability study laboratory	Bckgrnd > 3 x Bckgrnd > 2 mR/hr	Continue work Consult RHM[6] Establish REZ[7]	Prior to purging well as needed in treatability laboratory	Daily

Note 1: expl = explosion
Note 2: pot = potential
Note 3: def = deficient
Note 4: ab = above background
Note 5: N/A = not applicable
Note 6: RHM = Radiation Health Manager
Note 7: REZ = radiation exclusion zone

6.1 CALIBRATION SPECIFICATION

Instrument	Gas	Span	Reading	Method
PID: HNU, 10.2 ev probe	100 ppm isobutylene	9.8 ± 2.0	55 ppm	1.5 l/m reg T-tubing 0.25 l/m reg direct tubing
PID: HNU, 11.7 ev probe	100 ppm isobutylene	5.0 ± 2.0	68 ppm	1.5 l/m reg T-tubing 0.25 l/m reg direct tubing
FID: OVA-128	100 ppm methane	3.0 ± 1.5	100 ppm	1.5 l/m reg T-tubing

6.2 RADIOLOGICAL MONITORING EQUIPMENT AND PROCEDURES

Radiation Exposure:

Radiation exposure levels will be continuously monitored with portable instrumentation. Depending on the site, such instrumentation may include a simple personal monitor such as a Victoreen "Mini-Rad," ranging to more sophisticated portable G.M. or scintillation radiation detector instruments. Choice of instrumentation will be based on the site hazard evaluation and will be made after consultation with the company Radiation Health Officer (RHO).

Personnel Monitoring (External and Internal Dosimetry):

Personnel will wear thermoluminescent dosimeters (TLDs) for measurement of external radiation dose. In addition, self-reading dosimeters (SRDs) are required for work in radiation areas (areas where the exposure rate is greater than 2.5 mR/hr). TLDs will be processed on at least a quarterly basis.

Personnel who work in radiologically controlled areas will participate in a routine bioassay (internal dosimetry) program. This program will include baseline sampling to determine if previous uptakes of radioactive material have occurred, as well as routine bioassay sampling during fieldwork to detect any uptake of radioactive material. The scope of the bioassay program will be site-specific and must be determined in advance with the assistance of the company RHO.

Posting:

Areas where radioactive materials are present and/or elevated radiation fields may be present, must be posted as a Controlled Area at a minimum. When exposure rates reach 2.5 mR/hr or greater, the area must be posted as a "Radiation Area" at a minimum.

Contamination Control:

Samples taken in a radiologically controlled area (or at a site where radioactive materials may be present) will be surveyed with a G.M. pancake detector to determine gross beta/gamma contamination levels, and with an alpha scintillation detector if alpha contamination is suspected. Instruments or equipment used for well data or sample collection and analysis will be surveyed with a G.M. pancake detector as they are withdrawn from the well or borehole. Intermittent checks for alpha contamination will be made if alpha contamination is a possibility.

Personnel working in a radiologically controlled area must monitor periodically (at a minimum between samples, at breaks, and prior to exist from the site) for personal contamination. Proper techniques for checking for personal contamination shall be used. Limits for equipment are listed in Table 1.

Radiation Work Permits:

A Radiation Work Permit (RWP) is required in advance for work for which any of the following conditions are anticipated or possible:

- When an individual may receive a radiation dose in excess of 20 mrem to the total body or 300 mrem to the extremities during the work shift.
- When an individual may be exposed to airborne concentrations of radioactive material in excess of the 40-hr week guide for that material (Derived Air Concentration [DAC] or Maximum Permissible Concentration [MPC]).
- If radiologically controlled area posting is required to control the spread of known or suspected contamination.
- When intrusive characterization efforts may encounter radioactive contaminants of unknown types and/or concentrations.

Health Physics Coverage:

Health physics technicians are assigned monitoring responsibilities for locations with known radioactive contamination or radiation exposure rates greater than background. These technicians are responsible for determining natural background radiation exposure levels in areas known to be free of contamination, delineating areas of elevated radiation exposure and/or contamination, and monitoring personnel and equipment for radiation exposure and contamination.

Action Levels–External Radiation Exposure:

- Background to 2.5 mR/hr–continue routine operations.
- 2.5 mR/hour to 10 mR/hr–alert level; recheck for proper operation of radiation monitoring equipment, monitor radiation level every 10 minutes; take special care to minimize the possibility of inhalation or ingestion of related materials. Notify the Project Manager and the PGDP staff. If the area is outside of posted radiation areas, determine the boundary for the area above 2.5 mR/hr and mark and post it as a radiation area as specified in DOE 5480.11 and the CH2M HILL RSP manual. An RWP is required for work in a radiation area. If an RWP has not been approved in advance, work must stop until an RWP is initiated and approved.
- Above 10 mR/hr–provide for orderly shutdown of sampling or monitoring operations without sacrifice of program integrity. Determine area of radiation readings above 2.5 mR/hr and post it. Notify Project Manager and the PGDP staff, and do not reenter area until plan is amended.
- Above 20 mR/hour–provide for orderly shutdown of sampling and monitoring activities and evacuate area as quickly as possible. Notify Project Manager and PGDP staff. Working from outside the area, determine the boundary for the area above 2.5 mR/hr and mark and post it.
- In accordance with DOE and NRC regulations, if project work activities result in radiation levels in any area outside of the site such that a major portion of a person's body could be exposed to a dose of 5 mrem over 1 hour or 100 mrem over a period 5 consecutive days, the area will be posted as a radiation area and secured to minimize the potential for radiation exposure to members of the public.

Action Levels–Surface Contamination:

DOE Order 5480.11 specifies radiation levels of surface contamination for uncontrolled release of materials. The levels are the same as those in U.S. NRC Regulatory Guide 1.86 and American National Standards Institute, Inc. (ANSI) draft Standard N13.12. Surveys of material or equipment for unrestricted release will be conducted using RSP Procedure 7.0, "Evaluation of Surface Contamination on Articles to be Released for Unrestricted Use." In most cases, information on the isotopic breakdown of contamination will not be available because clearance surveys will be performed using gross α and gross β/γ counting techniques. The release criteria species in Table 1 are therefore set at the most restrictive limits recommended by DOE and NRC for unknown isotopes.

Table 1 Recommended Maximum Contamination Guide for Unrestricted Release of Equipment or Material			
Direct Survey		Transferrable (Smear Survey)	
Alpha	Beta Gamma	Alpha	Beta Gamma
DPM/100 cm^2		DPM/100 cm^2	
200	1,000	20	200[a]

[a]Except I-125, I-129, and Ac-227 for which the guide is 20 DPM/100 cm^2.

Note: No 100 cm^2 area to average greater than this value.

These criteria for surface contamination will be used for assessing surface contamination of sampling equipment and boots and clothing. The control of surface contamination is important for health and safety and is also important to prevent contamination of samples. Fixed and removable contamination levels should be determined using the most sensitive instrumentation available.

Portable field instrumentation (i.e., thin-end window GM detectors for beta-gamma, and alpha scintillation detectors) should be used at a minimum during sampling operations to determine gross fixed plus removable contamination levels.

Removable contamination levels should be determined using low contamination background smear counting systems. Removable surveys should be conducted periodically (at least twice each day) during field sampling operations.

RESIDUALS HANDLING:

Precipitate and used filters from the treatability laboratory may contain residual radionuclides. This section will address proper handling techniques.

7.0 DECONTAMINATION SPECIFICATION (REFERENCE STANDARDS OF PRACTICE)

Personnel	Sample Equipment	Heavy Equipment
• Boot wash/rinse	• Wash/rinse equipment	• Power wash
• Glove wash/rinse	• Solvent rinse equipment	• Steam clean
• Outer glove removal	• Solvent disposal method:	• Water disposal method:
• Body suit removal		
• Inner glove removal		
• Respirator removal		
• Hand wash/rinse		
• Face wash/rinse		
• Shower ASAP		
• PPE disposal method:		
• Water disposal method:		

7.1 DIAGRAM OF PERSONNEL DECONTAMINATION LINE

8.0 SPILL CONTAINMENT PROCEDURES

9.0 WORK PROCEDURES

9.1 WORK PRACTICES

- No spark sources within exclusion or decontamination zones or laboratory.
- Avoid visibly contaminated areas.
- No eating, drinking, or smoking in contaminated areas, or exclusion or decontamination zones.
- SSC to establish areas for eating, drinking, smoking.
- No contact lenses in exclusion or decontamination zones.
- No facial hair that would interfere with respirator fit if Level C or B is anticipated.
- Site work will be performed during daylight hours whenever possible. Any work conducted during hours of darkness will require enough illumination intensity "to read a newspaper without difficulty."

9.2 SITE CONTROL MEASURES

- Site safety coordinator (SSC) to conduct site safety briefing (see below) before starting field activities, or as tasks and site conditions change.
- SSC records safety briefing attendance in logbook, and documents topics discussed.
- Post OSHA job site poster in a central and conspicuous location at the site.
- Determine wind direction.
- Establish work zones: support, decontamination, and exclusion zones, and delineate work zones with flagging or cones as appropriate. Support zone upwind of site.
- Establish decontamination procedures, including respirator decontamination procedures, and test.
- Utilize access control at the entry and exit from each work zone.
- Chemicals to be stored in proper containers.
- MSDSs are available for onsite chemicals employees exposed to.
- Establish onsite communications. These should consist of:
  - Line of sight/hand signals
  - Air horn
  - Two-way radio or cellular phone if available
- Establish emergency signals. For example:
  - Grasping throat with hand--EMERGENCY--HELP ME
  - Grasping buddy wrist--LEAVE AREA NOW
  - Thumbs up--OK, UNDERSTOOD
  - Two short blasts on air horn--ALL CLEAR
  - Continuous air horn--EMERGENCY--EVACUATE
- Establish offsite communications.
- Establish "buddy" system.
- Establish procedures for disposal of material generated onsite.
- Initial air monitoring conducted by SSC in appropriate level of protection.
- SSC to conduct periodic inspections of work practices to determine effectiveness of this plan. Deficiencies to be noted and corrected.
- Site safety briefing topics: general discussion of health and safety plan; site specific hazards; location of work zones; PPE requirements; equipment; special procedures; emergencies.
- Laboratory analyses are to be conducted in a certified laboratory safety ventilation hood.

10.0 EMERGENCY RESPONSE PLAN (REFERENCE STANDARD OR PRACTICE)

10.1 PRE-EMERGENCY PLANNING

The SSC performs the applicable pre-emergency planning tasks before starting field activities and coordinates emergency response with the facility and local emergency service providers as appropriate.

- Locate nearest telephone to the site and inspect onsite communications.
- Locate chemical, safety, radiological, biological hazards.
- Confirm and post emergency telephone numbers and route to hospital.
- Post site map marked with location of emergency equipment and supplies.
- Review emergency response plan for applicability to any changed site conditions, alterations in onsite operations, or personnel availability.
- Evaluate capabilities of local response teams.
- Where appropriate and acceptable to the client, inform emergency room/ambulance service and emergency response teams of anticipated types of site emergencies.
- Designate one vehicle as the emergency vehicle; place hospital directions and map inside; keep keys in ignition during field activities.
- Inventory and check site emergency equipment and supplies.
- Review emergency procedures for personnel injury, exposures, fires, explosions, chemical and vapor releases with field personnel.
- Locate onsite emergency equipment and supplies of clean water.
- Verify local emergency contacts, hospital routes, evacuation routes, and assembly points.
- Drive route to hospital.
- Review names of onsite personnel trained in first aid and CPR.
- Review notification procedures for contacting CH2M HILL's medical consultant and team member's occupational physician.
- Rehearse the emergency response plan once prior to site activities.
- Brief new workers on the emergency response plan.

10.2 EMERGENCY EQUIPMENT AND SUPPLIES

The SSC marks the locations of emergency equipment on the site map and posts the map in the support zone.

- 20 lb ABC fire extinguisher
- Industrial first aid kit
- Facility emergency equipment:
- Additional emergency equipment:

10.3 EMERGENCY MEDICAL TREATMENT

- The SSC will assume charge during a medical emergency until the ambulance arrives, or the injured person is admitted to the emergency room.
- Prevent further injury.
- Initiate first aid and CPR.
- Call the ambulance and hospital.
- Determine if decontamination will make injury worse. Yes--seek medical treatment immediately.
- Make certain that injured person is accompanied to emergency room.
- Notify the Project Manager of the injury.
- Notify the District or Regional Health and Safety Manager.
- Notify the injured person's human resources department.
- Prepare an incident report to the Site Health and Safety Officer.

10.4 EVACUATION

- Evacuation routes will be designated by SSC prior to beginning of work.
- Onsite and offsite assembly points will be designated prior to beginning of work.
- Personnel will exit the exclusion zone and assemble at the onsite assembly point upon hearing the emergency signal for evacuation of the exclusion zone.
- Personnel will assemble at the offsite point upon hearing the emergency signal for a site evacuation.
- The SSC and a "buddy" will remain onsite after the site has been evacuated (if possible) to assist local responders and advise them of the nature and location of the incident.
- SSC accounts for all personnel in the onsite assembly zone.
- A person designated by the SSC (prior to work) will account for personnel at the offsite assembly area.
- The SSC is to write up the incident as soon as possible after it occurs, and submit a report to the Corporate Director Health and Safety.

10.5 EVACUATION ROUTES AND ASSEMBLY POINTS

10.6 EVACUATION SIGNALS

Exclusion Zone	Site

11.0 EMERGENCY RESPONSE TELEPHONE NUMBERS

SITE ADDRESS:	**Phone:**
Police: **Address:**	**Phone:** 911 (verify)
Fire: **Address:**	**Phone:** 911 (verify)
Ambulance: **Address:**	**Phone:** 911 (verify)
Water:	**Phone:**
Gas:	**Phone:**
Electric:	**Phone:**
Hospital: **Address:**	**Phone:**

Route To Hospital: **(Refer to map Page 20.)**

11.1 GOVERNMENT AGENCIES INVOLVED IN PROJECT

Federal:	**Phone:**
State:	**Phone:**
Local:	**Phone:**

THIS PAGE RESERVED FOR MAP OF ROUTE TO HOSPITAL

12.0 EMERGENCY CONTACTS

Medical Consultant	**Occupational Physician (Regional or Local)**
Corporate Director Health and Safety Name: Phone:	**Site Safety Coordinator (SSC)** Name: Phone:
District Health and Safety Manager (DHSM) Name: Phone:	**Regional Manager** Name: Phone:
Regional Health and Safety Manager (RHSM) Name: Phone:	**Project Manager** Name: Phone:
Radiation Health Manager (RHM) Name: Phone:	**Regional Human Resources Department** Name: Phone:
Client	**Corporate Human Resources Department** Name: Phone: If an injury occurs, notify the injured person's personnel office as soon as possible after obtaining medical attention for the injured. Notification MUST be made within 24 hours of the injury.

13.0 PLAN APPROVAL
This site safety plan has been written for use by _____. _____ claims no responsibility for its use by others, unless specified and defined in project or contract documents. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if these conditions change.
PLAN WRITTEN BY: **DATE:**
PLAN APPROVED BY: **DATE:**
13.1 PLAN AMENDMENTS
DATE: CHANGES MADE BY:
CHANGES TO PLAN:
APPROVED: **DATE:**
13.2 PLAN AMENDMENTS
DATE: CHANGES MADE BY:
CHANGES TO PLAN:
APPROVED: **DATE:**
14.0 ATTACHMENTS TO PLAN
Attachment 1: Employee signoff **Attachment 2:** Form 533 **Attachment 3:** Applicable MSDSs

ATTACHMENT 1

EMPLOYEE SIGNOFF

The employees listed below have been provided a copy of this health and safety plan, have read and understood it, and agree to abide by its provisions.

EMPLOYEE NAME	EMPLOYEE SIGNATURE / DATE

ATTACHMENT 2

FORM 533
RECORD OF HAZARDOUS WASTE FIELD ACTIVITY

SITE NAME:
SITE SAFETY COORDINATOR:
PROJECT NUMBER:
RECORD OF ACTIVITIES FOR (DATES):

EMPLOYEE NAME/NUMBER	TOTAL DAYS ONSITE	DAYS IN LEVEL B	DAYS IN LEVEL C	DAYS IN LEVEL D	DAYS AS SSC LEVEL B	DAYS AS SSC LEVEL C	DAYS AS SSC LEVEL D	ACTIVITIES PERFORMED

ATTACHMENT 3

APPLICABLE MSDSs

This attachment will be added to conform to site-specific requirements.